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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

MICROGRAVITY SCIENCE GLOVEBOX (MSG) INVESTIGATION INTERFACE REQUIREMENTS DOCUMENT

Microgravity Science Applications Department
Glovebox Program Office
and
Systems Engineering Division

MSFC Form 454 (Rev. October 1992)

MSG INVESTIGATION INTERFACE REQUIREMENTS DOCUMENT
MSFC-RQMT-2888

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Change No./Date	SCN/DCN No./Date	CCBD No./Date	Replacement Page Instructions
	N/A	GB3-02-0001 5/30/00 GB00135	Basic Release
CH 1 REV A	DCN-001	GB3-02-0007 GB00157 12/18/00	Revision A Release. Revision A replace the Basic Release in its Entirety and Incorporate DCN-001
CH 2 REV B	DCN-002	GB3-02-0013 GB00213 6/26/01	Revision B Release. Revision B replace the Rev A in its Entirety and Incorporate DCN-002
CH 3 REV C	DCN-003	GB3-02-0060 GB00394 6/13/02	Revision C Release. Revision C replace the Rev B in its Entirety and Incorporate DCN-003
CH 4 REV D	DCN-004	GB3-02-0114 GB00480 4/09/03	Revision D Release. Revision D replace the Rev. C in its Entirety and Incorporate DCN-004

NOTE: After revising the document, file this sheet in document preceding Table of Content

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1.0 SCOPE

This Investigation Interface Requirements Document (IIRD) defines and controls required Investigation interfaces for compatibility with the Microgavity Science Glovebox (MSG). The applicability of these requirements will depend upon the characteristics of the integrated MSG Investigation. The interface design requirements outlined in this document are mandatory and may not be violated unless specifically agreed upon in the individual Investigation Interface Control Document (ICD). This document is under the control of the MSG Investigation Integration Team (IIT) and the MSG Integration Level III Configuration Control Board (CCB) will approve any changes or revisions.

This IIRD is the interface design requirements document for Microgravity Science Glovebox (MSG) Investigations. Compliance with the IIRD is mandatory to certify an Investigation for integration into the MSG. This includes the United States Laboratory (USL), Columbus Orbiting Facility (COF), and Multi-Purpose Logistics Module (MPLM). NSTS 1700.7, ISS Addendum, KHB 1700.7, ISS Addendum and NSTS 18798 provide the safety requirements for Investigation design.

The physical, functional, and environmental design requirements associated with Investigation safety and interface compatibility are included herein. The requirements defined in this document apply to ground handling and processing, passive stowage transportation in the MPLM and Middeck, and on-orbit phases of the Investigation operation. Additional transportation requirements specific to the carrier, or requirement changes due to characteristics of the integrated MSG Investigation shall be identified in the Investigation Unique ICD. The on-orbit requirements have been derived form SSP-57000, Pressurized Payloads Interface Requirements Document. The SSP-57000 requirements incorporated into this IIRD are the ones identified as an applicable requirement to an Investigation in SSP-57211, MSG Hardware ICD. The integrated systems test Investigations are required to perform with the Engineering Unit, in the investigation's flight configuration, have been identified as an integrated rack test in SSP-57411, Microgravity Science Glovebox Verification Plan, Volume 1. The integrated test results are used to satisfy ISS verification requirements. All updates to SSP-57000 incorporated in this document are identified in Appendix G. The interface requirements defined herein address the MSG to Investigation interface and any rack specific requirements were derived from information on the MSG facility in the MSG-RIBRE-RP-0002, MSG Design Definition Document, MSG-RIBRE-RQ-001, MSG Payload Accommodation Handbook and MSG System Specification, MSG-RIBRE-SPE-0001. Any deviations to the requirements herein must first be approved by the MSG Integration Level III CCB.

1.1 Use

This document levies design, interface and safety verification requirements on MSG Investigation developers and/or integrators. These requirements are allocated to an Investigation through the Verification Matrix in the unique Investigation Interface Control Document. This document defines the interfaces between the MSG and the Investigation. Paragraphs within this document that say "**the Investigator shall**" indicates that the requirement must be verified. Paragraphs within this document that say " **the Investigator will**" are for design information only. Engineering units and conversions will be per FED-STD-376. Investigations can either use ANSIY14.5M or DIN 7168 to determine tolerances for interface locations.

1.2 Configuration Management

This document is under control of the MSG Integration Level III Configuration Control Board (CCB) and the MSG CCB Chairperson must approve any changes or revisions.

1.3 Payload Description

The MSG is a rack facility to be accommodated initially in the USL of the ISS. The MSG consists of an International Standard Payload Rack (ISPR, NASDA Version) and associated infrastructure, stowage drawers, rack front panel, and the Core Facility. This IRD will focus primarily on the Core Facility and its associated components, since these components provide direct interface to the Investigations.

The MSG facility provides an enclosed work area for Investigation manipulation and observation. This work area can serve as an environment that is isolated from the manned atmosphere, via negative pressure and constantly circulating air, or as a work area open to the manned atmosphere.

Capabilities of the MSG facility are fully described in the MSG Capabilities Manual, MSFC-HBDK-3051.

Figures 1 through 2 provide various views of the MSG rack and its components. Figure 2 gives the MSG attachment (inserts) and connector locations to aid in the design of the Investigation's cables and hoses.

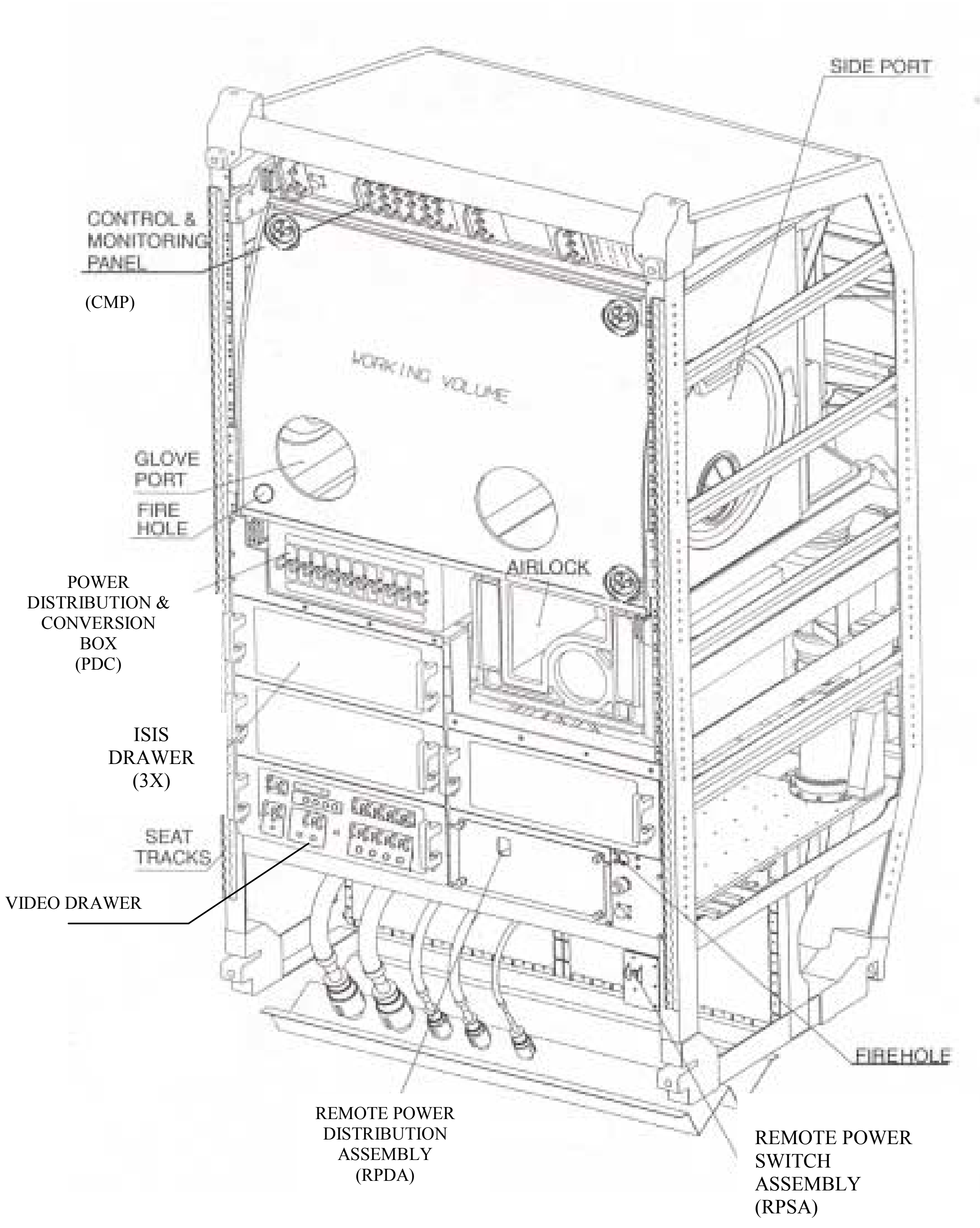
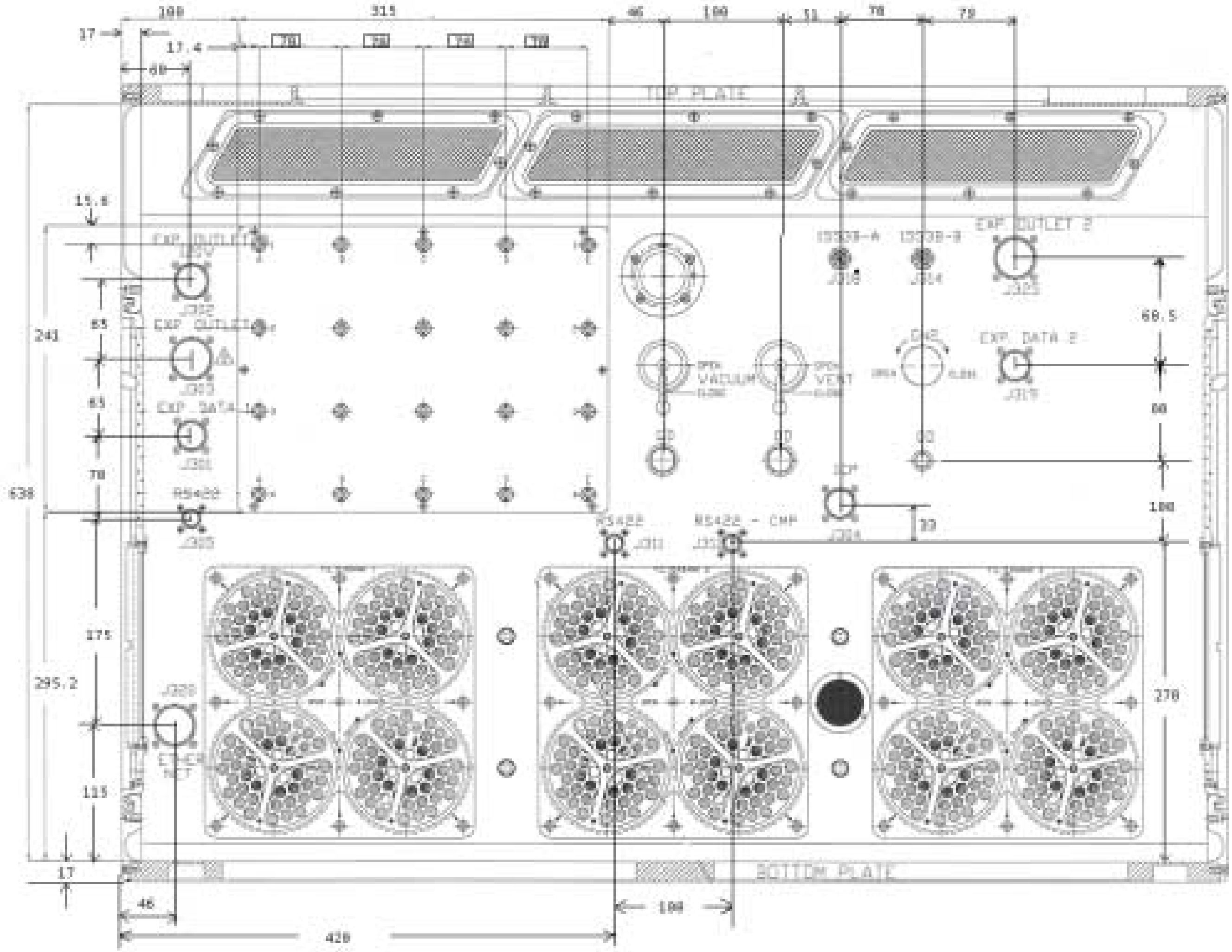


Figure 1. MSG Isometric View



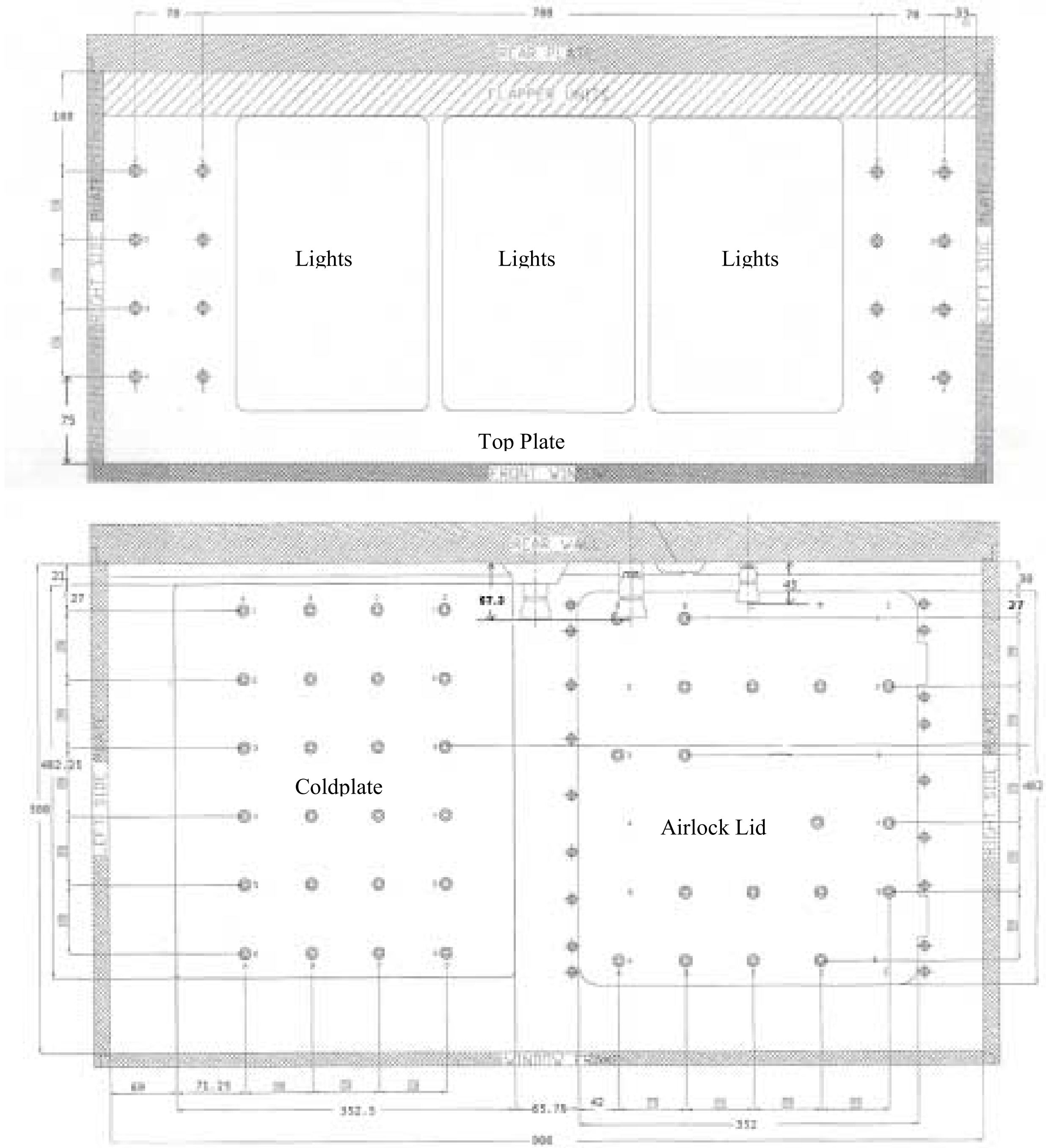
Note:

1) Dimensions are in Millimeters
2) Drawing not to scale
3) Tolerances to DIN 7168 or ANSIY14.5M
4) Connectors, sensors and handle protrusion dimensions into WV:

J303/325: 24mm, J302: 24mm, J301/304/319: 27mm, J314/318 25mm, J305/311/312 22mm, J320 18mm
Humidity and temp sensor: 25mm, vacuum handles 49.3mmn GN2, 38.1mm

5) The material of the MSG work volume is 7075 aluminum nickel struck

Figure 2. M6 Threaded Fastener and Connector Locations



Note:
1) Dimensions are in Millimeters
2) Drawing not to scale
3) Tolerances to DIN 7168 or ANSIY14.5M
4) Connector savers (not shown) are along the WV sides above the loading ports. The size depends if a connector is attached.

Figure 2. M6 Threaded Fastener and Connector Locations (Cont.)

2. APPLICABLE DOCUMENTS

The latest version of the following documents form a part of this document to the extent specified herein. In the event of conflict of requirements between this document and other related project documents, the following order of precedence shall apply: applicable NASA safety requirements, applicable ISS requirements, applicable NSTS requirements, MSG Investigation Interface Requirements Document, and other documents specified herein.

FED-STD-209	Airborne Particulate Cleanliness Classes in Classrooms And Clean Zones
FED-STD-376	Preferred Metric Units for General Use by the Federal Government
FED-STD-595B	Federal Standard Colors Used in Government Procurement
JSC-36044C	Space Station Mission Operations Acronyms and Abbreviations
JSC 27260	Decal Process Document and Catalog
KHB 1700.7	Space Shuttle Payload Ground Safety Handbook
MIL-STD-1553B Notice 2	Digital Time Division Command/Response Multiplex Data Bus
MIL-C-5541	Chemical conversion coating on Aluminum and Aluminum Alloys
MIL-M-3171	Magnesium Alloys, Processes for Pretreatment and Prevention of Corrosion
MIL-STD-1686	Electrical Discharge Control Program for Protection of Electrical and Electrical Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) Document
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for Control of Electromagnetic Interfaces
MIL-STD-45662A	Calibration Systems Requirements
MIL-STD-130G	Identification Marking of U. S. Military Property
MIL-STD-1189	Standard Department of Defense Bar Code Symbology
MSFC-HDBK-3051	MSG Capabilities Manual

MSFC-HDBK-527/ JSC 09694	Material Selection List for Space Hardware Systems
NASA-STD-6001, Test 7	Flammability, Odor, Offgassing, and compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion
NSTS 13830C	Payload Safety Review and Data Submittal Requirements
NSTS 1700.7 ISS Addendum	Safety Policy and Requirements for Payloads using the Space Transportation System
KHB 1700.7B ISS Addendum	Space Shuttle Payload Ground Safety Handbook
NSTS 18798	Interpretations of NSTS/ISS Payload Safety Requirements
NSTS-21000-IDD-MDK	Shuttle/Payload Interface Definition Document for Middeck Accommodation
SSP-52050	Software Interface Control Document Part 1, ISS Payload Rack to ISS
SSP-57211	Microgavity Science Glovebox Interface Control Document
SSP-57311	Microgavity Science Glovebox Software Interface Control Document
SSP-57411	MSG Verification Plan.
SSP 30237	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP 50254	Operations Nomenclature
SSQ 21655	Cable, Electrical, MIL-STD-1553 Data Bus, Space Quality, General Specification for Document
SSP 50007	Bar Code Requirements
SSP 41000	System Specification for the ISS
SSP-57000	Pressurized Payloads Interface Requirements Document

MSFC-PLAN-3052	MSG Investigation Integration Plan
ISO/IEC 8802-3	Information Technology – Local and Metropolitan Area Networks, formerly known as ANSI/IEEE 802.3
EIA STD RS-232C	Electrical Standards for RS-232
MSFC-RQMT-3098	Software Specification for Microgravity Science Gloveblox Laptop Server Software
DIN 7168	General Tolerances for Linear and Angular Dimensions and Geometrical Tolerances
ANSIY14.5M	The Application of Geometric Tolerancing Techniques
NSTS/ISS 13830	Implementation Procedures for NSTS Payloads System Safety Requirements
NSTS 07700	Volume XIV, Attachment 1, (ICD 2-19001), Shuttle Orbiter/Cargo Standard Interfaces
JSC 27472	Requirements for Submission of Data Needed for Toxicological assessment of Chemicals and Biologicals to be Flown on Manned Spacecraft
MSG-ORIGIN-IC-0001	Interface Control Document MSG Data Handling System
MSFC-HDBK-3168	MLC Users Guide
EIA-RS-170	Electrical Performance Standards for Television Studio Facilities
SSP 57020	Pressurized Payload Accommodation Handbook
SSP 50467	Cargo Stowage Technical Manual: Pressurized Volume
SSP 30512	Space Station Ionizing Radiation Design Environment
MSG-RIBRE-RP-0002	MSG Design Definition Document
MSG-RIBRE-RQ-0001	MSG Payload Accommodation Handbook
MSG-RIBRE-SPE-0001	MSG System Specification

3.0 INVESTIGATION INTERFACE REQUIREMENTS AND GUIDANCE

The requirements contained in this section will be complied with in order to certify an Investigation for integration into the MSG WV and the ISS USL.

3.1 Structural/Mechanical, Microgravity and Stowage Interface Requirements

3.1.1 Structural/Mechanical

3.1.1.1 Loads Requirements

a. Investigations will be designed to withstand the launch and landing conditions when stowed in the MPLM or Middeck. For design consideration the Investigation will use the acceleration loads defined in Table I. These loads are based on a worst case condition of the Middeck and MPLM.
It is assumed that the loads imposed by the random vibration environment on stowed items in foam can be neglected in design consideration**.** The Investigation will conduct a workmanship test, for instance on electrical components or mechanisms, based on the random vibration environment defined in Table I. The Investigation must ensure that the hardware will survive the workmanship random vibration level.

b. Investigations will be limited to ground transportation accelerations of 80% of the flight loads identified in paragraph 3.1.1.1.a of this IRD.

c. Investigations shall be designed to withstand the on-orbit loads of 0.2 Gs acting in any direction.

d. Investigation hardware located outside of the WV shall be designed to maintain positive margins of safety when exposed to (ultimate and yield) the crew-induced loads as defined in Table II.

Table I. Investigation Launch and Landing Conditions

Liftoff	**X**	**Y**	**Z**
(g)	±9.0	±11.6	±9.9
Landing			
(g)	±6.25	±7.7	±12.5

Table I. Investigation Launch and Landing Conditions Cont.

Frequency (Hz)	Amplitude
20	0.0005 G^2/Hz
20 - 150	6.0 dB/octave
150 - 1000	0.03 G^2/Hz
1000 - 2000	-6.0 dB/octave
2000	0.0075 G^2/Hz
Composite	6.5 G_{rms}

Note: Environment based on worst random vibrations in Space Shuttle mid-deck lockers.

Table II. Crew-Induced Loads

Crew System or Structure	Type of Load	Load	Direction of Load
Levers, Handles, Operating Wheels, Controls	Push or Pull Concentrated on most extreme edge	50 lbf, limit (222.5 N)	Any Direction
Small Knobs	Twist (torsion)	11 ft-lbf, limit (14.9 N-M)	Either Direction
Cabinets and any normally exposed equipment	Load distributed over a 4 inch by 4 inch area	125 lbf, limit (556.4 N)	Any direction

3.1.1.2 Additional Investigation Requirements

a. Investigations shall be limited to a control weight for on-orbit operations of 200 kg (440 lbs). MSG provided equipment in the WV shall be included in this on-orbit weight limit. Investigation control mass shall be documented in the Investigation Increment Specific ICD.

b. Investigations shall be designed to withstand the MPLM depress rate of 878 Pa/sec (7.75 psi/min) and repress rate of 800 Pa/sec (6.96 psi/min).

c. Investigation equipment will be designed not to create a hazard when exposed to the Portable Fire Extinguisher (PFE) discharge.

The WV is not considered a part of containment for rotating parts. The Investigation is required to address any rotating parts during the safety reviews.

3.1.1.3 Attachment Provisions

The Investigation shall participate in a physical and integrated interface verification of the investigation hardware at least once during the development and integration process per the MSG Investigation Integration Plan, MSFC-PLAN-3052. The integrated test requires that the investigation test in its flight configuration and verify all interfaces with the MSG. The last date for accomplishing this interface/integrated test is nine months prior to Launch. Investigation size relative to the MSG work volume, may require an earlier fit check to ensure that margins are not compromised. This earlier physical fit check should be accomplished by ISR timeframe. These tests will require delivery of the investigation hardware to MSFC. A Customer Agreement is necessary for IIT to process any investigation hardware at MSFC, as described below:

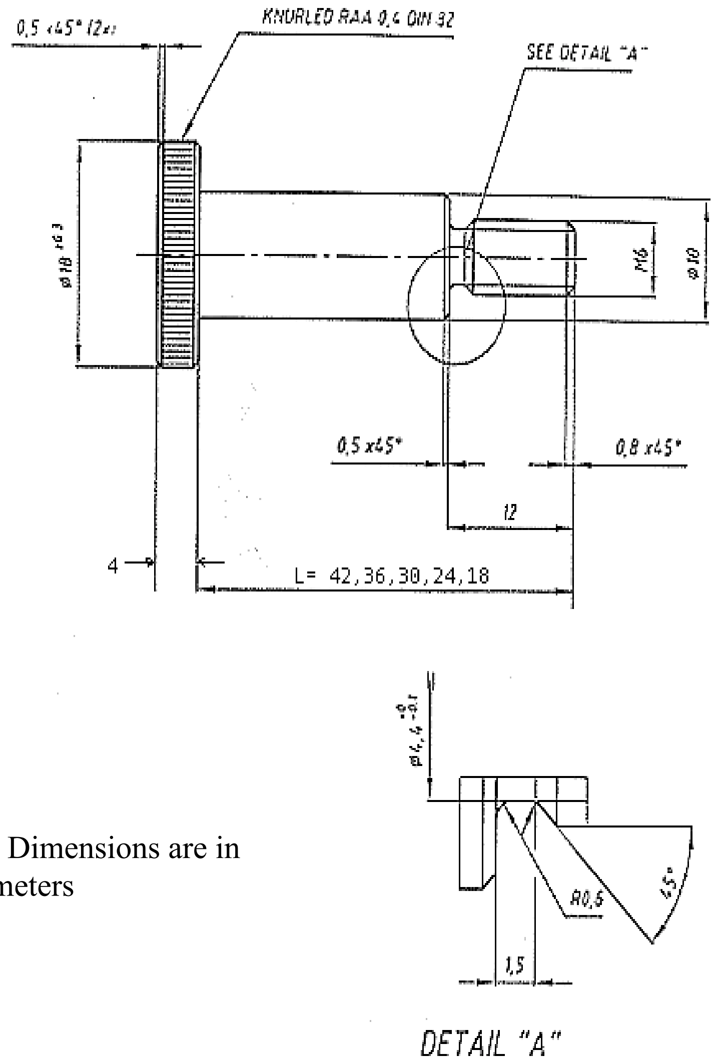
- The Investigation hardware must have either an internal or external customer agreement as appropriate.
- All Investigation hardware must comply with the MSFC policies for product identification and traceability and customer supplied product agreements.
- A pre-test meeting will be held to review test plans and procedures. Representatives of the Facility manager, IIT, and Quality will attend this meeting.
- Facility test procedures will be run to verify the Facility is ready for integration or testing with Investigation Hardware in its flight configuration.
- The Investigations must complete a pre-integration test procedure prior to interfacing with the facility to preclude damage to the Facility. Verification items that must be closed prior to testing in the engineering unit (EU) are identified on the VDS.
- Activities required of the Investigation prior to an accessing the Facility includes but is not limited to:
- Verification of CSP tag (if applicable)
- Sharp edge inspection
- Electrical interface verification requirements
- C&DH interface verification requirements

Mounting of Investigation hardware will vary depending on the type of hardware and the location of the hardware within the MSG (i.e. Work Volume or Airlock). Primarily the hardware is mounted using M6 x 1.0 pitch threaded inserts located throughout the WV. These M6 x 1.0 pitch threaded inserts are located in the WV coldplate, airlock lid, top of the WV, side loading ports and on the rear wall of the WV. The location of these inserts is shown in Figures 2 and 5. It is recommended that Investigations using a four hole pattern for attachment that one or two of the holes provide some slop in them.

There are five lengths of M6 fasteners being supplied by MSG to interface with the M6 inserts. The difference in the fasteners is the shank length. The shank lengths provided by MSG are 30 mm, 24 mm, 18 mm, 12 mm and 6 mm. The overall fastener dimensions are detailed in Figure 4. Investigations that plan on using these fasteners shall provide a means of keeping the fastener captive, either physically or operationally.

Investigation provided captive fasteners shall be of type M6 x 1.0 pitch thread with an engagement of 5mm to 10 mm.

Figure 3. <u>Deleted</u>

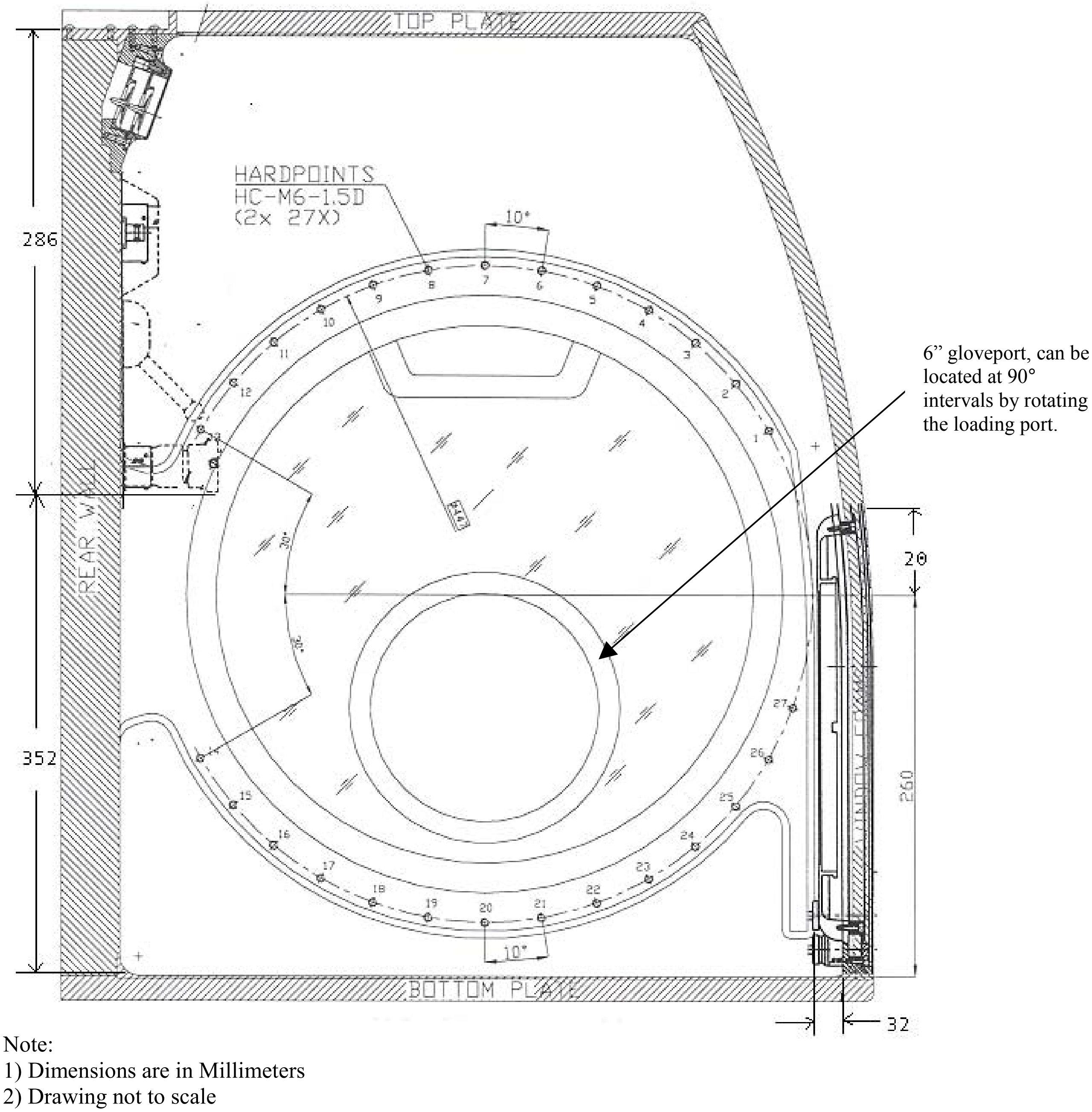


Note: Dimensions are in millimeters

Figure 4. Threaded Fastener Dimensions

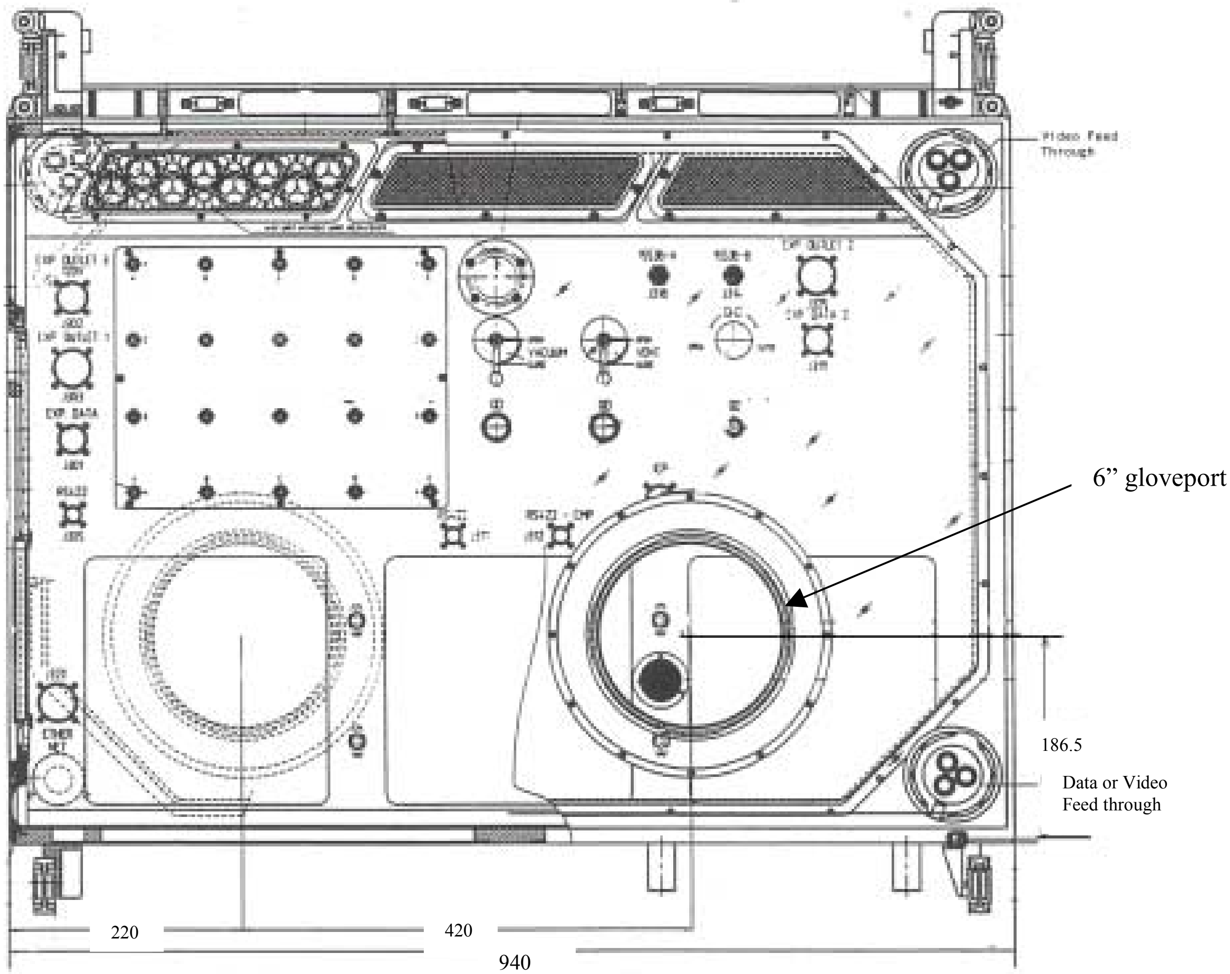
3.1.1.3.1 Bungee Cords

Bungee cords can be used to secure equipment in the WV and to the Airlock tray, used for transferring equipment in and out of the WV. Investigations will provide any bungee cords required for unique methods of attachment. MSG will provide 100mm, 150mm and 200mm length bungee cords.



Note:
1) Dimensions are in Millimeters
2) Drawing not to scale
3) Tolerances to DIN 7168 or ANSIY14.5M

Figure 5. Loading Port M6 Threaded Fastener and Gloveport Locations



Note:
1) Dimensions are in Millimeters
2) Drawing not to scale
3) Tolerances to DIN 7168 or ANSIY14.5M

Figure 5. Loading Port M6 Threaded Fastener and Gloveport Locations Cont.

3.1.2 Microgravity

Microgravity requirements are defined to limit the disturbing effects of the investigation on the microgravity environment of other payloads during microgravity mode periods. These requirements are separated into three categories the quasi-steady category for frequencies below 0.01 Hz, the vibratory category for frequencies between 0.01 Hz and 300 Hz, and the transient category. Investigations will be given a vibration disturbance allocation (TBE#1). This allocation has not been determined and will be sub allocated from MSG rack data. Investigation hardware, which will remain on-orbit after UF-3, shall meet the subsequent requirements.

3.1.2.1 Quasi-Steady Requirements

For frequencies below 0.01 Hz, Investigations shall limit unbalanced transitional average impulse to generate less than 10 lb-s (44.8 N-s) within any 10 to 500 second period along any ISS coordinate system vector.

3.1.2.2 Vibratory Requirements

Between 0.01 Hz and 300 Hz, Investigations shall limit vibration so that the limits of Figure 6 (TBD #1) are not exceeded using the force method. The total force at each interface point will be calculated to be the root-summed squared (RSS) in all axis, within each third octave band, during the worst case 100 second interval.

3.1.2.3 Transient Requirements

Investigations shall limit force applied to the MSG over any ten second period to an impulse of no greater than 10 lb-s (44.5 N-s). Investigations shall limit their peak force applied to the MSG to less than 1000 lb (4448 N) for any duration.

NOTE: Meeting the transient requirements does not obviate the need to also meet the 100 second vibration requirement of 3.1.2.2 for vibration included in and following the transient disturbance.

Figure is TBD

Figure 6. Allowable Vibration Forces (TBE #1)

3.1.2.4 Microgravity Environment

Refer to the Pressurized Payloads Accommodation handbook (PAH), SSP 57020 for microgravity environment data.

3.1.2.5 Angular Momentum Limits

This requirement applies only to investigation disturbance forces and moments that generate pure internal angular momentum impulse greater than 100 ft-lb-sec (135 N-m-sec) or a maximum impulse greater than 1.1 lb-s (5.2 N-s) over any continuous period of 9 minutes. Investigations that generate angular momentum impulses, as stated above, shall work with the MSG Investigation Integration Team (IIT) to determine the applicability and evaluate the ability of investigations to meet the limits of ISS.

3.1.3 Stowage Input Requirements

Investigations requiring individual stowage shall address their requirements for stowage planning. Stowage items requiring Late or Early access, special environmental control or orientation requirements while in stowage will be worked with the MSG IIT on a case by case basis. The Investigation's stowage requirements shall be documented in the Unique Investigation ICD.

Investigations shall provide the IIT with engineering sketches or drawings showing the individual hardware items to be stowed dimensions, part number and part name. These drawings will reside in the Unique Investigation ICD and shall be used to determine that the volume allocation in the ICD is not exceeded.

Investigations shall provide the IIT with the mass of each individual hardware item being stowed. The mass of the hardware items shall be included in the Unique Investigation ICD and shall be used to determine that the mass allocation in the ICD is not exceeded. Hardware items weighing greater than 30 lbs (13.6 kg) being stowed in the Middeck and 50 lbs (22.7 kg) in the MPLM shall provide center of gravity parameters. Moment of inertia and products of inertia are required for items above 50 lbs. The investigator is referred to NSTS 21000-IDD-MDK for size constraints concerning the Middeck lockers and SSP 50467, Cargo Stowage Technical manual: Pressurized Volume, for additional stowage interface information.

Any waste/trash generated by the Investigations shall be identified for planning of dedicated handling & treatment.

3.2 Electrical Interface Requirements

The MSG receives, conditions, and distributes electrical power from the ISS Electrical Power System (EPS) to the MSG WV for use by the Investigation. The MSG will allocate and control available power as needed to accomplish its mission.

The Investigation is provided a maximum of 1000 W of power inside the MSG WV. The following primary and secondary Investigation power interfaces are provided inside the WV.

- Investigation Primary Power
  RPDA +120 Vdc Power (120 Vdc, 8.3 A)
- Investigation Secondary Power
  - RPDA +28 Vdc Power, (+28 Vdc, 7 A)
  - RPDA +12 Vdc Power, (+12 Vdc, 2 A)
  - RPDA - 12 Vdc Power, (-12 Vdc, 2 A)
  - RPDA +5 Vdc Power, (+5 Vdc, 4 A)

It should be noted that the Investigation secondary power sources are converted voltages derived from the DC/DC converters in the Core Facility.

A block diagram showing the WV electrical interfaces is shown in Figure 7.

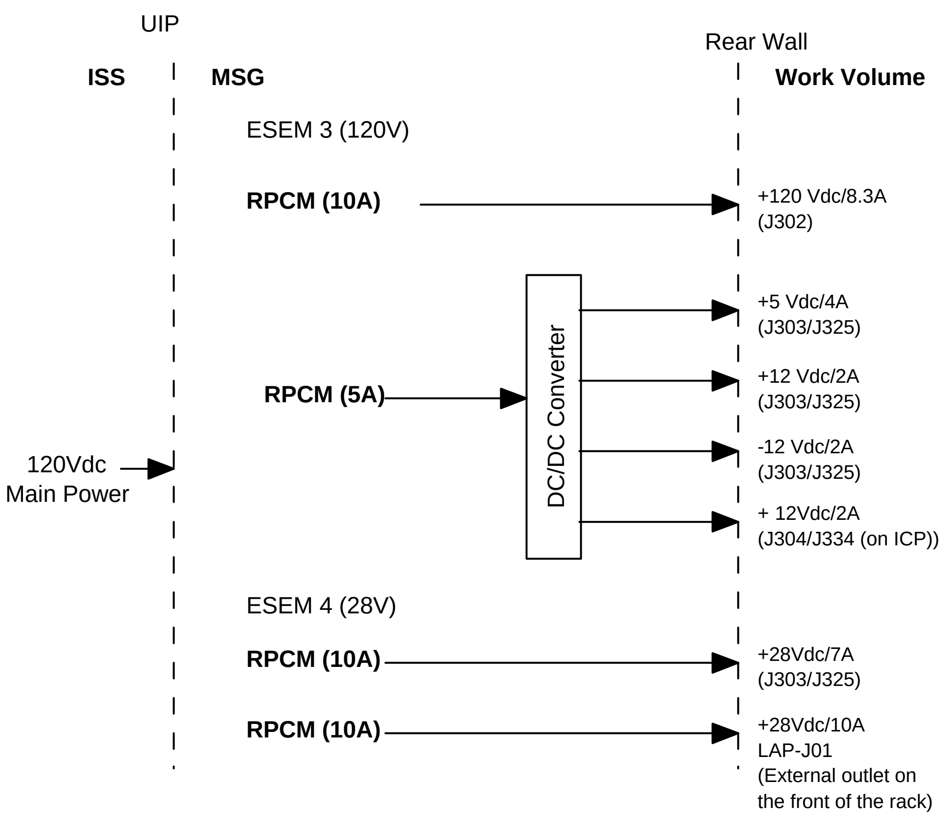


Figure 7. <u>WV Electrical Interface Block Diagram</u>

3.2.1 Electrical Power Characteristics

a. The total power consumption from all Investigation voltages shall not exceed 1000 Watts (i.e. if an Investigation is using 120 volts at 8.3 amps, then none of the other voltages available to the Investigation can be used at that time).

b. The Investigation hardware connected to any of the above power sources shall be compatible with characteristics prescribed herein. "Compatible" is defined as not producing an unsafe condition or one that may result in damage to ISS equipment, the MSG integrated rack, or Investigation hardware.

3.2.1.1 Steady-State Voltage Characteristics

The Investigation Electrical Power Consuming Equipment (EPCE) shall be compatible with steady-state voltage limits defined in Table III.

Table III. Steady-State Voltage Limits

Nominal Voltage	Voltage Range	Current Range	Power
+120 Vdc	RPDA output Voltage Drop on CF~0.4*Iexp Test values at CF interface are +111.9 to +126.0 Vdc	Useable 8.3A	1000 W
+28 Vdc	RPDA output Voltage Drop on CF~0.2*Iexp Test values at CF interface are +26.8 to +28.4 Vdc	0.7 to 7 A*	196 W*
+12 Vdc	+11.7 to +12.4 Vdc	0.2 to 2 A*	24 W*
-12 Vdc	-11.4 to –12.4 Vdc	0.2 to 2 A*	24 W*
+5 Vdc	+5.0 to +5.2 Vdc	0.4 to 4 A*	20W*

Note: The test values for the 120V range were taken at input voltage at the UIP of 112V to 116V and 122V to 126V at 8.3 amps. The values used for the voltage range are actual test values of the flight unit. * Total amount for both secondary experiment interfaces J303 & J325.

3.2.1.2 Ripple Voltage Characteristics

3.2.1.2.1 Ripple Voltage and Noise

The Investigation EPCE shall operate and be compatible with the RPDA time domain ripple voltage and noise levels defined in Table IV.

Table IV. RPDA Ripple Voltage and Noise Limits

RPDA Power Source	Ripple Voltage/Noise Level	Frequency Bandwidth
+120 Vdc	2.5 V_{rms} maximum	30 Hz to 10 kHz
+28 Vdc	100 mVpp	$\geq$50 MHz
+ 12 Vdc	< 50 mV_{pp}	1 Hz to 1 MHz
-12 Vdc	< 50 mV_{pp}	1 Hz to 1 MHz
+5 Vdc	< 50 mV_{pp}	1 Hz to 1 MHz

3.2.1.2.2 Ripple Voltage Spectrum

The Investigation EPCE connected to the 120 Vdc WV primary power source shall operate and be compatible with the ripple voltage spectrum as shown in Figure 8.

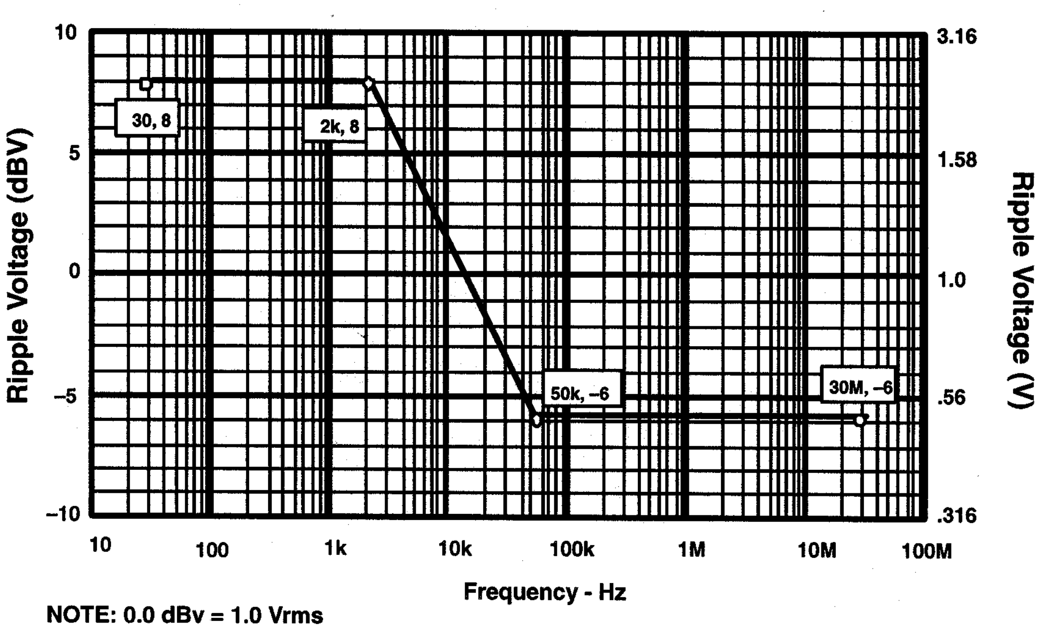


Figure 8. Maximum Voltage Ripple (Spectral Components)-120 Vdc

3.2.1.3 Transient Voltages

The Investigation EPCE connected to the 120 Vdc WV primary power source shall be compatible with the limits of magnitude and duration for the voltage transients as shown in Figure 9. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple and/or random noise components that may be present.

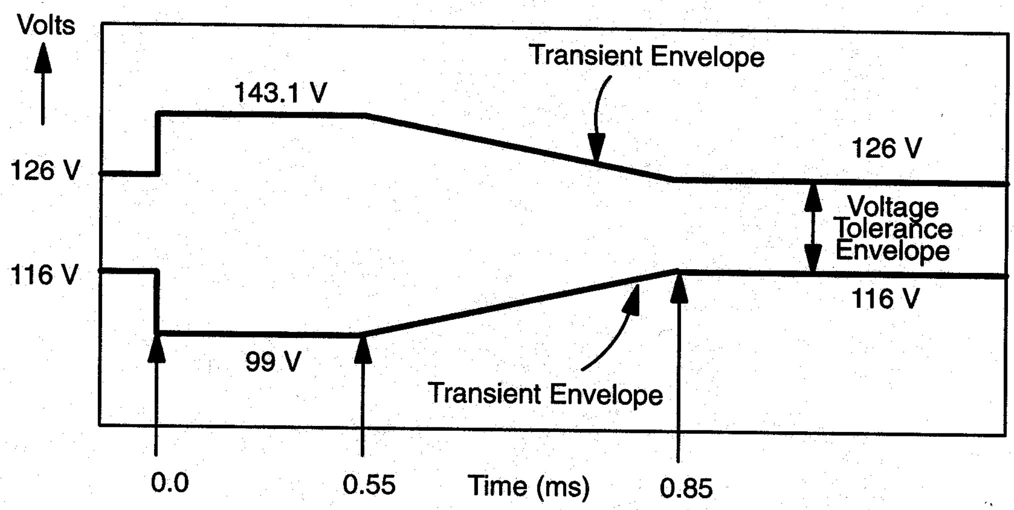


Figure 9. Transient Voltages -120 Vdc

3.2.1.3.1 Fault Clearing and Protection

a. The Investigation EPCE connected to the 120 Vdc WV primary power source shall be safe and not suffer damage with the fault clearing and protection transient voltage limits shown in Figure 10.

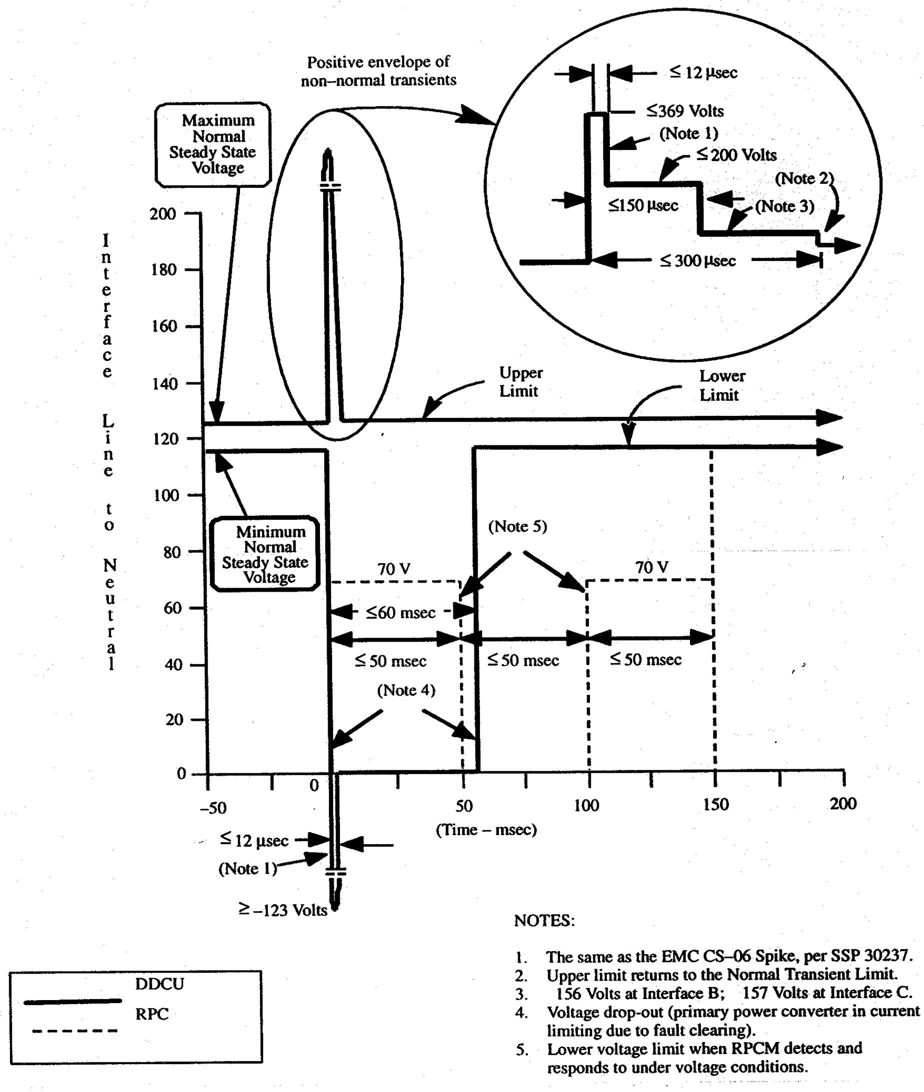


Figure 10. **Fault Clearing & Protection Transient Limits-120 Vdc**

b. The Investigation EPCE connected to the 28 Vdc WV secondary power source shall operate and be compatible with the limits of magnitude and duration for the voltage transients as shown in Figure 11.

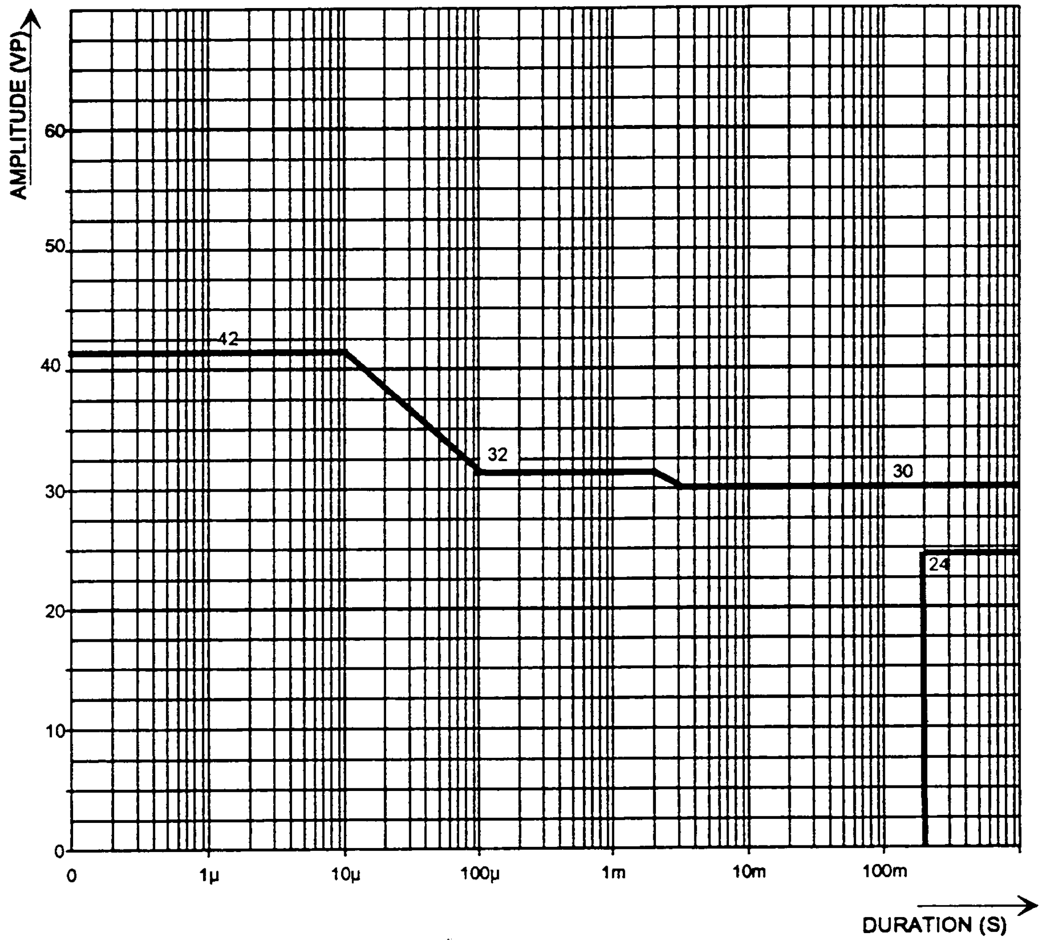


Figure 11. Transient Voltages for Abnormal Operations-28 Vdc

3.2.1.3.2 Non-Normal Voltage Range

The Investigation EPCE connected to the 120 Vdc WV primary power source shall not produce an unsafe condition or one that could result in damage to ISS equipment, MSG equipment or Investigation hardware with the non-normal voltage characteristics:

a. Maximum over-voltage of +165 Vdc for 10 sec.
b. Undervoltage of +102 Vdc for an indefinite period of time.

3.2.2 Electrical Power Interface

Investigation primary and secondary power is distributed in the WV. The primary and secondary power is supplied on separate connectors mounted in the WV rear wall. The power outlets can either be activated via the CMP switches or remotely controlled from inside the WV via the ICP.

3.2.2.1 Primary Power Connector

a. The WV Investigation primary power connector (J302) is supplied on a MS27656P17F6SA connector in the WV rear wall as shown in Figure 2. The connector characteristics and contact assignments are listed in Table V. The nominal voltage levels provided via this outlet are the ones available at the UIP reduced by a voltage drop inside the MSG of ~ 1.5VDC which results in nominal levels between 114.5 to 124.5 VDC.

b. The Investigation provided connector (P302) shall be of type MS27467T17F6PA and shall be compatible with the contact assignments defined in Table V.

c. The primary power connector contains an inhibit circuit via a solid state switch in the CMP (see Figure 12). Contacts D and E shall be bridged inside the Investigation circuitry to assure proper operation of the inhibit. It is required that the investigation place the inhibit link in the connector.

d. To insure a proper bonding path the Investigation shall either use pin F or the bonding requirements in section 3.2.4.2 and subs.

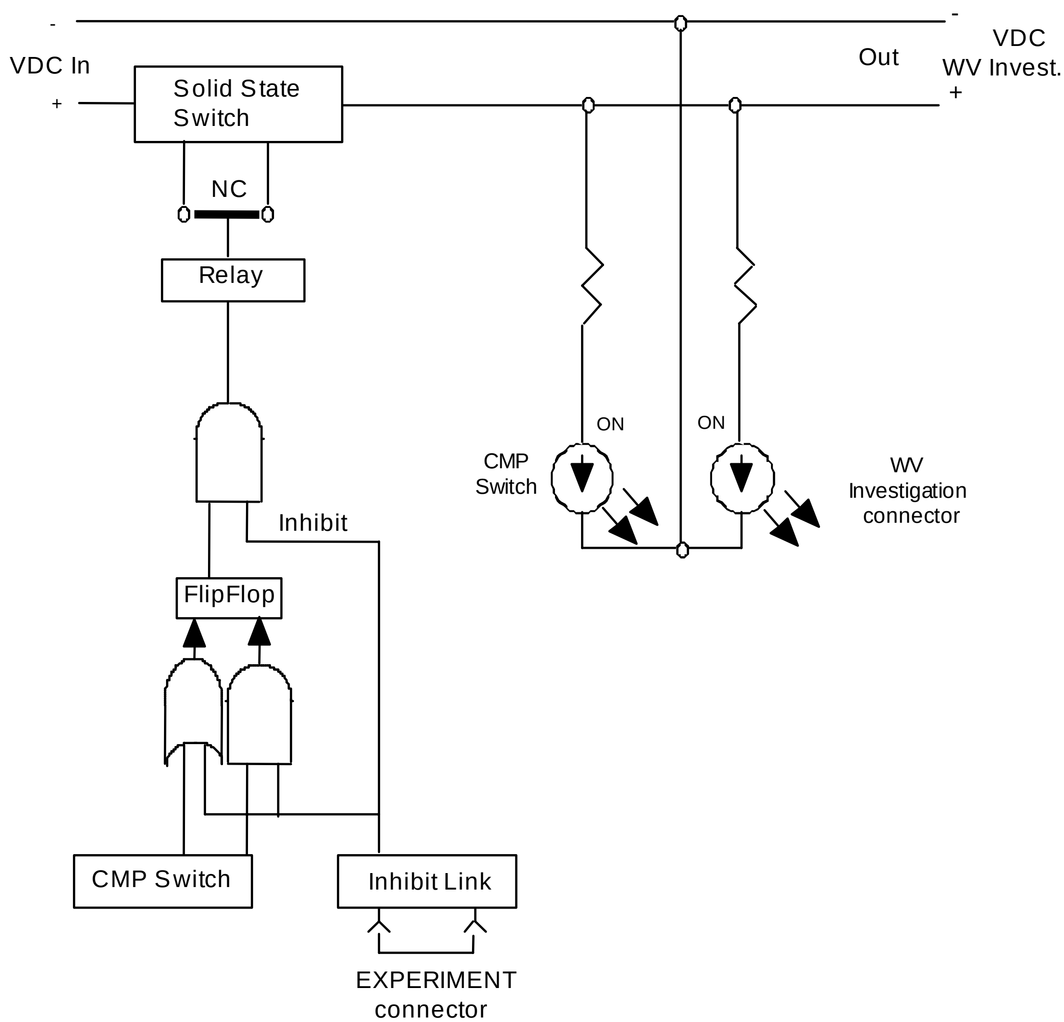


Figure 12. Power Line Inhibit Circuit

Table V. Primary Power Connector Contact Assignments

Connector Label: J302, Exp. Outlet 3, 120V	**Connector Type: MS27656P17F6SA**	
Contact	**Contact AWG**	**Function/Description**
A	12	+120 VDC Primary Power
B	12	RTN for 120 VDC Primary Power
C	12	Overall Shield
D	12	Inhibit J302
E	12	RTN for Inhibit J302
F	12	Chassis J302

3.2.2.2 Secondary Power Connector

a. The WV Investigation secondary power connectors (J303/J325) are supplied on two MS27656P21F11S connectors in the WV rear wall as shown in Figure 2. The Investigation is supplied with a 28V outlet (LAP-J01) on the front of the rack located to the left of the PDC box. The connector type and contact assignments are identical to J303 and J325 for the 28V interface. This interface is for the MLC only, the Investigator should refrain from using this interface. The connector characteristics and contact assignments are listed in Tables VI and VII.

b. The Investigation provided connectors (P303/P325/LAP-P01) shall be of type MS27467T21F11P and shall be compatible with the contact assignments defined in Tables VI and VII.

c. The secondary power connectors contains an inhibit circuit via a solid state switch in the CMP (see Figure 12). Contacts H and K shall be bridged inside the Investigation circuitry to assure proper operation of the inhibit. It is required that the investigation place the inhibit link in the connector.

d. To insure a proper bonding path the Investigation shall either use pin L or the bonding requirements in section 3.2.4.2 and subs.

e. Investigations will always apply 20% of the load being applied on the –12V line to the +12V line when using the –12V alone.

Table VI. Secondary Power Connector (J303) Contact Assignments

Connector Label: J303, Exp. Outlet 1	**Connector Type: MS27656P21F11S**	
Contact	**Contact AWG**	**Function/Description**
A	12	+28 VDC Power Secondary 1
B	12	RTN 28 VDC Power Secondary 1
C	12	+ 12 VDC Power Secondary 1
D	12	- 12 VDC Power Secondary 1
E	12	RTN 12 VDC Power Secondary 1
F	12	+ 5 VDC Power Secondary 1
G	12	RTN 5 VDC Power Secondary 1
H	12	Inhibit J303
J	12	Shield
K	12	RTN for Inhibit J303
L	12	Chassis J303

Table VII. Secondary Power Connector (J325) Contact Assignments

Connector Label: J325, Exp. Outlet 2	Connector Type: MS27656P21F11S	
Contact	**Contact AWG**	**Function/Description**
A	12	+28 VDC Power Secondary 2
B	12	RTN 28 VDC Power Secondary 2
C	12	+ 12 VDC Power Secondary 2
D	12	- 12 VDC Power Secondary 2
E	12	RTN 12 VDC Power Secondary 2
F	12	+ 5 VDC Power Secondary 2
G	12	RTN 5 VDC Power Secondary 2
H	12	Inhibit J325
J	12	Shield
K	12	RTN for Inhibit J325
L	12	Chassis J325

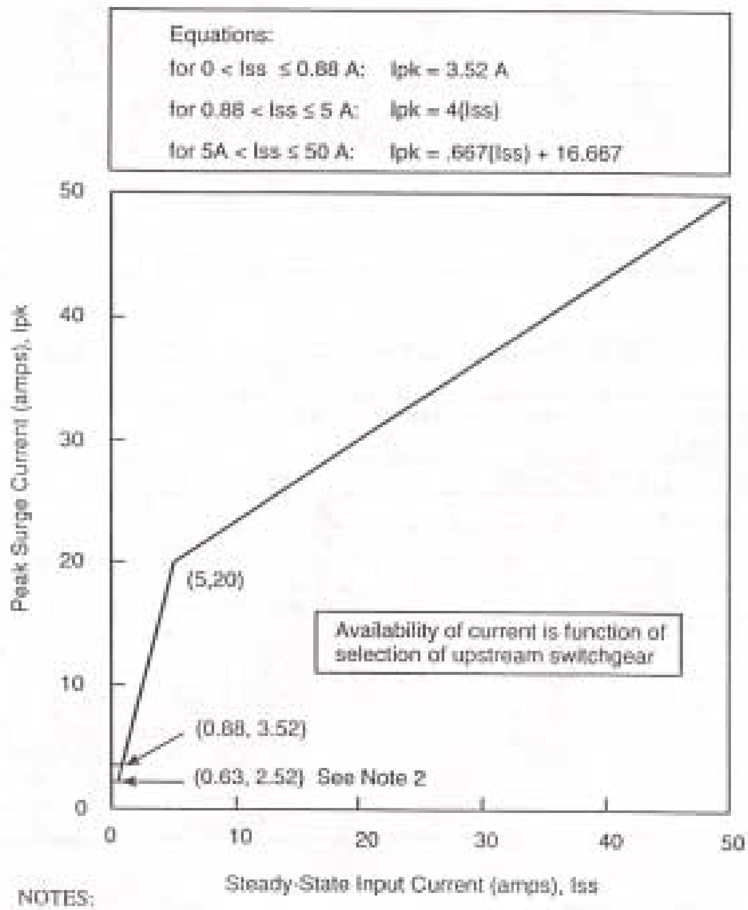
3.2.2.3 Surge Current

a. Investigation hardware connected to the 120 VDC WV primary power source available in the WV shall not exceed the surge current limits at the power inputs as defined in Figures 13 and 14. The duration of the surge current will not exceed 10 ms. These requirements apply to all operating modes and changes including power-up and power-down.

Note: The MSG 120 VDC switching hardware does not provide soft ON/OFF characteristics. Investigation hardware with capacitive input filters may have to incorporate a soft start design in order to meet the ISS surge current requirements.

b. The protection circuits for the 28 Vdc WV secondary power source accepts load inrush currents of $\leq 2 \times I_{NOM}$ for a duration of ≤ 10 µs without tripping. Investigation hardware connected to the 28 VDC WV secondary power source available in the WV shall be compatible with the trip characteristics given in Figure 20.

Surge current measurements shall be taken during the integrated test, for all investigations using either the primary or secondary power sources, with the MSG engineering unit to insure ISS requirements are met for Surge Current.



NOTES:

1. For transients less than 100 microseconds, refer to SSP 30237.
2. NASA Space Station equipment accommodated in JEM will have a maximum allowable peak surge current of 2.52 amps for equipment having a steady-state input no greater than 0.63 amps.

Figure 13. **Peak Surge Current Amplitude Versus Steady-State Input Current**

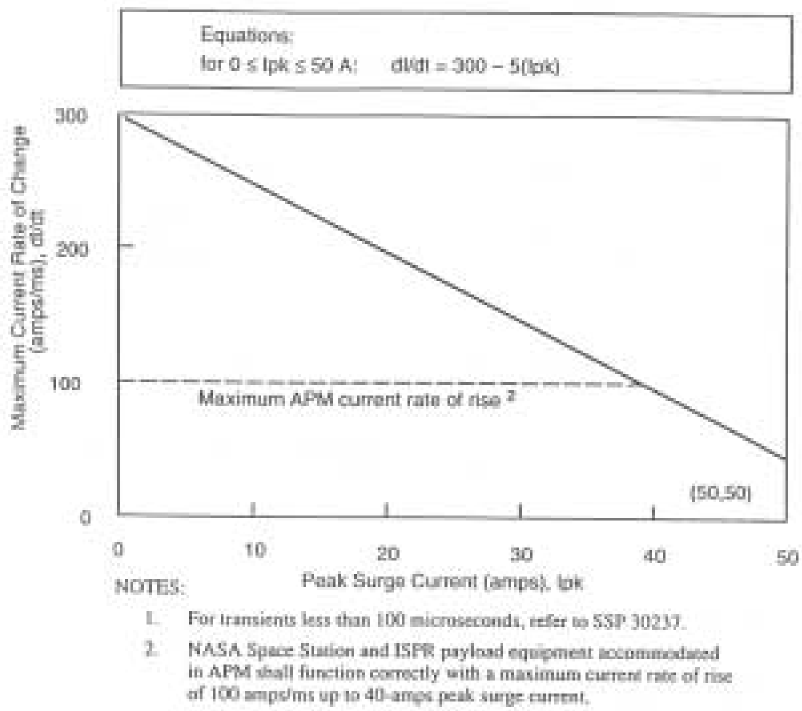


Figure 14. Maximum Current Rate of Change Versus Peak Surge Current Amplitude

3.2.2.4 Reverse Current

Investigation hardware connected to the 120 Vdc primary power source available in the WV must comply with the requirements defined in paragraph 3.2.2.4.1 or 3.2.2.4.2 for the reverse current into the upstream power source.

Note: Investigations having input connected capacitances, the aggregate total of which is less than 25 micro–farads, are considered meeting the limits of paragraph 3.2.2.4.1 for US Type I RPCMs. Input connected capacitors are those which, by virtue of circuit arrangement, are able to discharge through the power source when the power source is short circuited. Series connected rectifier diodes and resistors greater than 10 Ohms are sufficient to block such discharges.

3.2.2.4.1 Reverse Current Limits

Investigations using the 120V DC primary power sourse shall limit reverse current transients that can occur when a hard fault occurs across the power source within the applicable transient envelope shown in Figures 15, 16 and 17. For purposes of this interface definition, the fault is 10 milli Ohms or less applied within 2 micro–seconds or less. For the investigation hardware exhibiting reverse current transient peaks within ±100 Amperes, the fault resistance is 40 milli Ohms or less.

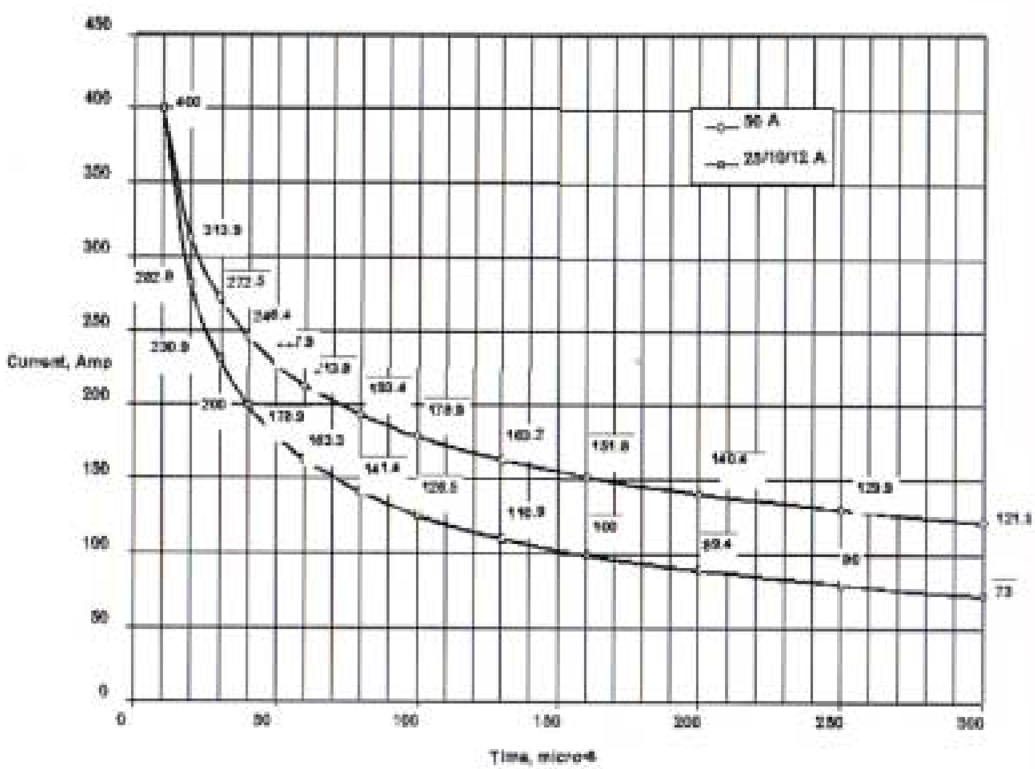


Figure 15. Reverse Current Envelopes for Time Duration Shorter Than 300 Microseconds

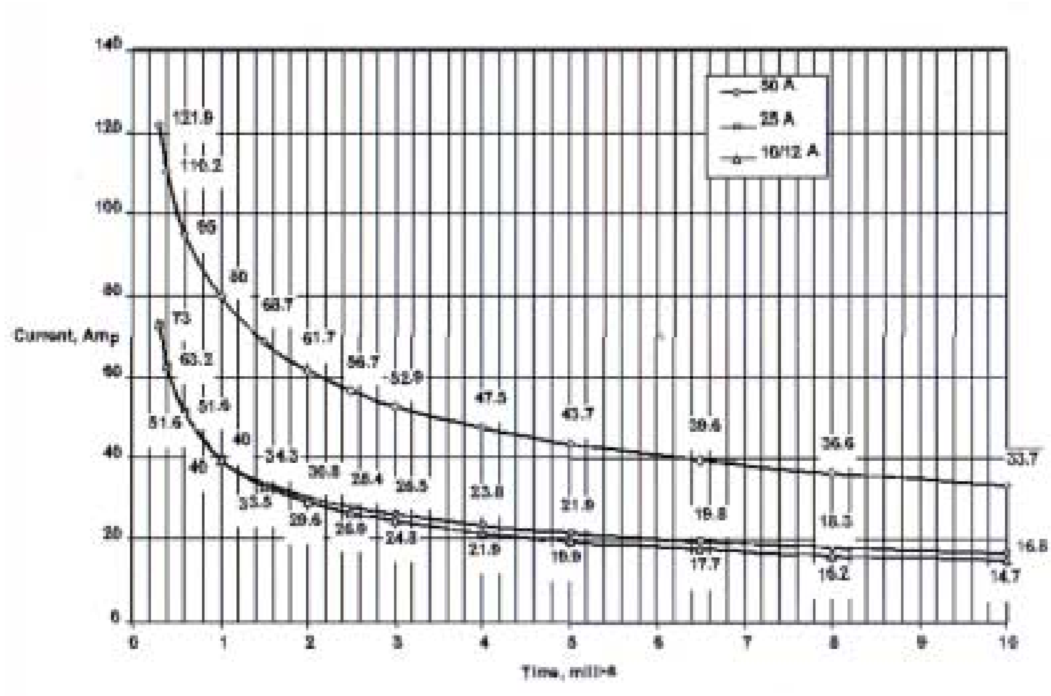


Figure 16. <u>Reverse Current Envelopes for Time Duration Between 300 Microseconds and 10 Milliseconds</u>

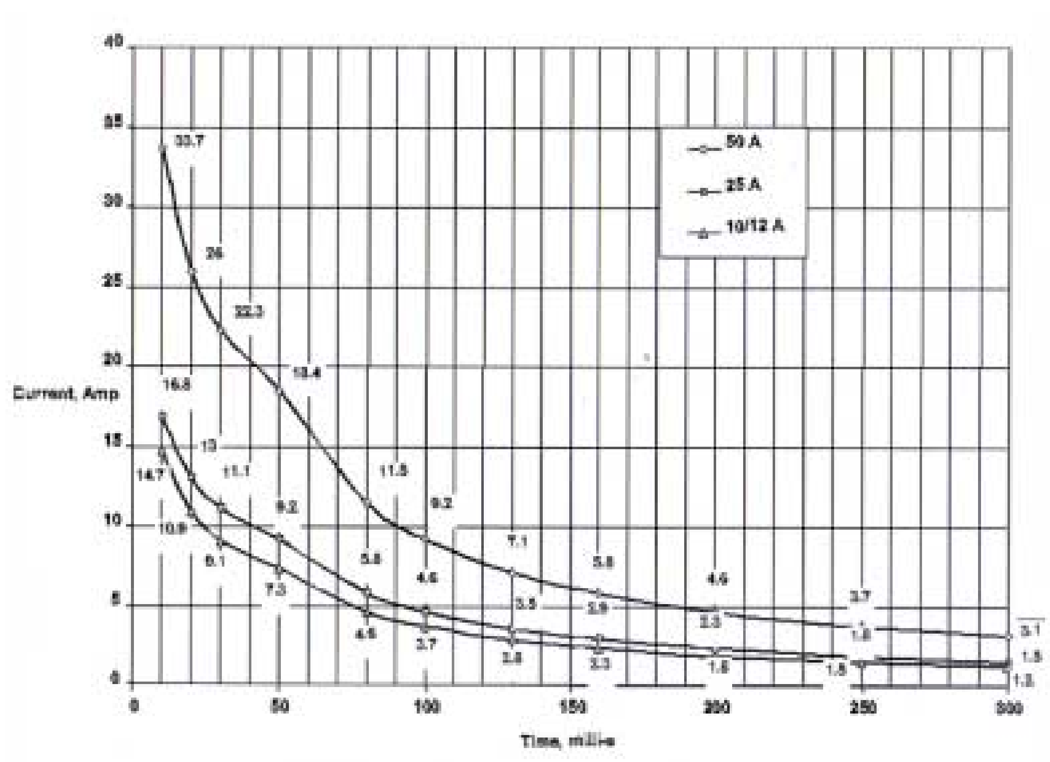


Figure 17. Reverse Current Envelopes for Time Duration Between 10 Milliseconds and 300 Milliseconds

3.2.2.4.2 Transients Partially Contained Within the Envelope

If the reverse current on the 120V DC primary power source exceeds the envelope limits defined in paragraph 3.2.2.4.1 for one or more short time intervals, the transient peak current and the ratio of the times of intersection with the envelope shall satisfy the following inequality:

$$(\underline{i_{pk}/}\ i_e)^2 \bullet \ln(\underline{t_2}/\ t_1) \ \underline{<}\ 1$$

Where 1n represents the natural logarithm, t_1 and t_2 correspond to the beginning and end times, respectively, of each interval when the transient is outside the envelope, i_{pk} is the peak of the transient occurring between t_2 and t_1, and i_e is the point on the envelope at the time of the peak i_{pk}. For multiple intervals in which the envelope is exceeded, the left–hand side of this expression will be evaluated for each interval and the sum of all such results will total less than unity.
Note:

1. This criterion is based on approximation of the real transient by a vertical–sided pulse which begins at t_1, follows a t_2 function through i_{pk} point, and ends at t_2. This vertical–sided pulse has the stress property equivalent to the stress that the RPCMs in USL can sustain.

2. An example of such a case is illustrated in Figure 18 where the transient for a hypothetical Load "A" is overlaid with the envelope for a US Type II RPCM, rated at 25 A. The figure shows the transient crossing the envelope at times t_1 = 5.1 ms and t_2 = 7.1 ms with a peak i_{pk} = 27.5 A and an envelope value, i_e = 21 A. Substituting these values into the left–hand side of the inequality in this paragraph leads to

$$(i_{pk} / i_e)2 \text{ x } \ln(7.1 / 5.1) = 27.5 / 21)2 \text{ x } 0.331 = 0.567$$

which satisfies the inequality, and since there are no additional envelope crossings, this calculation demonstrates compatibility.

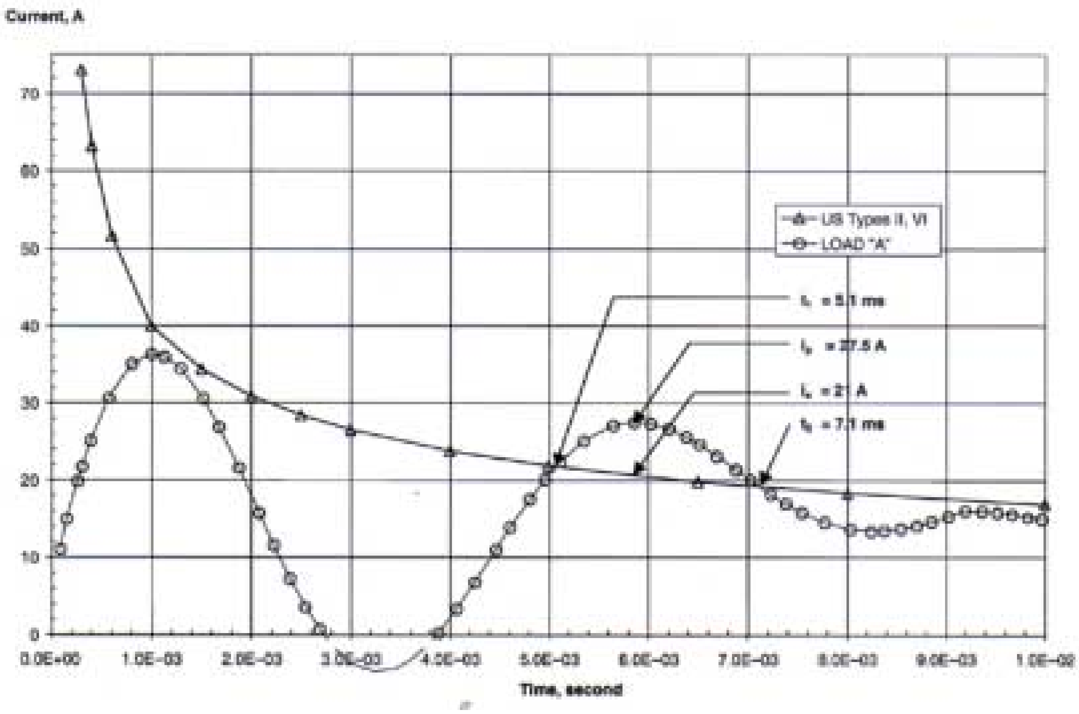


Figure 18. An Example of a Load Partially Contained Within the Envelope

3.2.2.5 Circuit Protection Devices

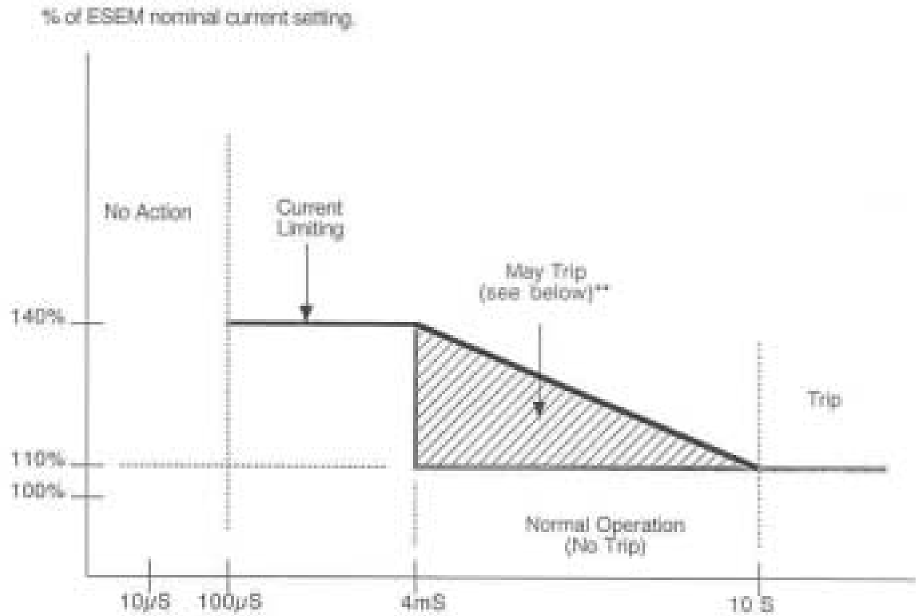
The RPDA 120 Vdc output modules provide local and remote over-current protection for the 120 Vdc WV primary power outlets and secondary power outlets. After tripping no automatic reset will be performed.

a. Investigation hardware connected to the 120 Vdc WV primary power source shall be compatible with the trip characteristics for the 120 Vdc power outlet given in Figure 19.

b. Investigation hardware connected to the 28 Vdc WV secondary power source shall be compatible with the trip characteristics of the 28 Vdc WV secondary power source specified in Figure 20.

c. Investigation hardware connected to the 5V secondary power source shall be compatible with a maximum inrush current of 2X nominal operating current for up to 10ms.

d. Investigation hardware connected to the ±12V secondary power source shall be compatible with a maximum inrush current of 2X nominal operating current for up to 10ms.



In the "No Action" area, no current limiting or Tripping will occur.

Between 100μSec. and 4 mSec., the current supplied by the ESEM will be limited to 140% of the nominal ESEM current setting.

**Between 4 mSec. and 10 Sec., if the conditions within the ESEM present a condition outside of the Safe Operating Area for the ESEM MOSFET switch, the unit will trip. This Safe Operating Area is dependent on Voltage across the switch, current, and temperature.

After 10 Sec., current levels in excess of 110% of the ESEM current setting will cause a trip.

Figure 19. **Trip Characterisitics-120 Vdc Power Outlet**

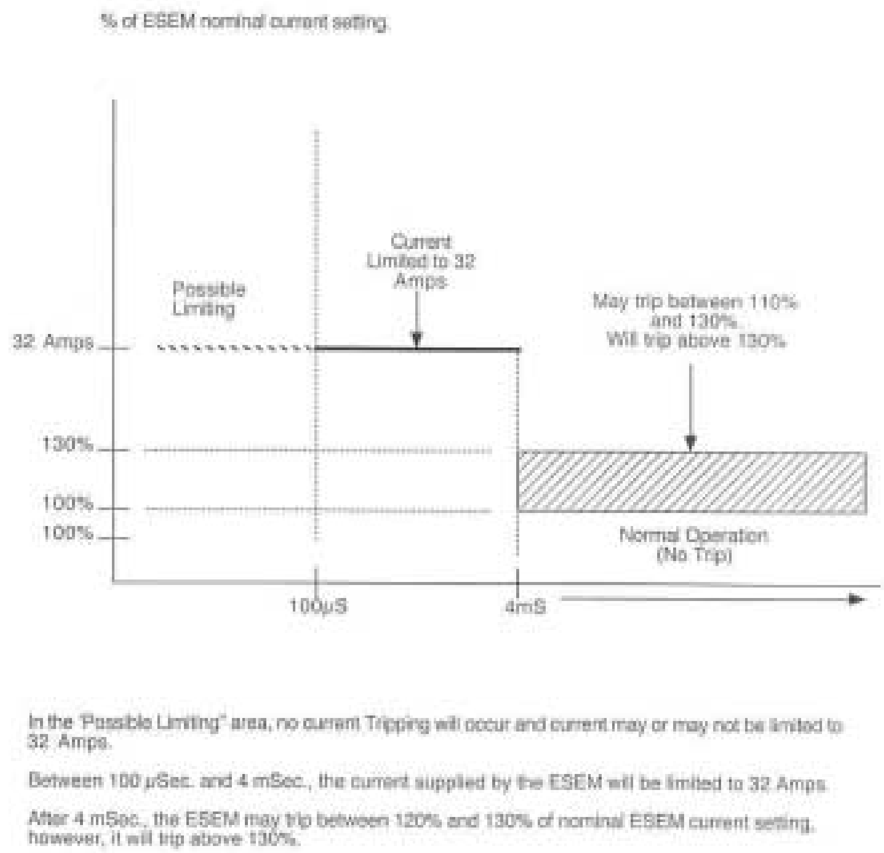


Figure 20. <u>Trip Characterisitics-28 Vdc Power Source</u>

3.2.2.6 Deleted

3.2.2.7 Investigation Complex Load Impedances

The load impedance presented by the investigation hardware connected to the 120 VDC interface shall not exceed the bounds defined in Figure 21 for input over the frequency range of 50 Hz to 100kHz. The magnitude component of the EPCE input impedance should not be less than the minimum defined in Figure 21. At frequencies where the magnitude component of the EPCE input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in this Figure.

Impedance measurements shall be taken during the integrated test, for all investigations using either the primary or secondary power sources**,** with the MSG engineering unit to insure ISS requirements are met for Complex Load Impedance.

3.2.2.8 Large Signal Stability

The investigation hardware connected to the 120 VDC interface shall maintain stability with the ISS electrical power system interface by damping a transient response to 10 percent of the maximum response amplitude within 1.0 millisecond, and remaining below 10 percent thereafter under the following conditions:

1. The rise time/fall time (between 10 and 90 percent of the amplitude) of the input voltage pulse is less than 10 microseconds.

2. The voltage pulse is to be varied from 100 to 150 microseconds in duration.

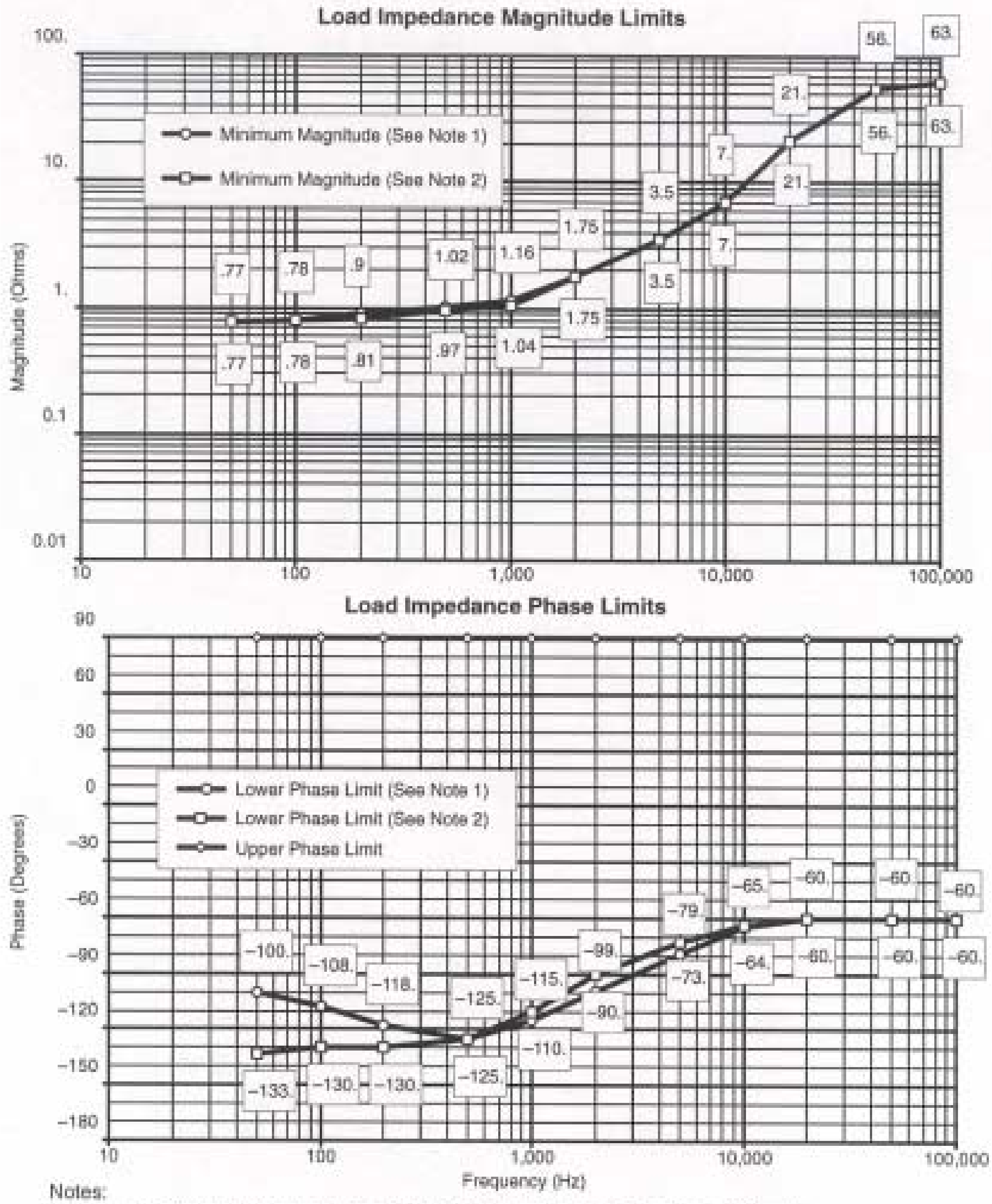
Note: Figure 22 is used to clarify the above requirement.

Large Signal Stability measurements shall be taken during the integrated test, for all investigations using either the primary or secondary power sources, with the MSG engineering unit to insure ISS requirements are met for Large Signal Stability.

3.2.2.9 Electrical Load-Stand Alone Stability

An Investigation connected to the RPDA power sources available in the WV shall provide local stability by meeting the following conducted susceptibility requirements:

a. Section 3.2.4.4.2.2.1 (CS01)
b. Section 3.2.4.4.2.2.2 (CS02)
c. Section 3.2.4.4.2.2.3 (CS06)



Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

Figure 21. Investigation Complex Load Impedances

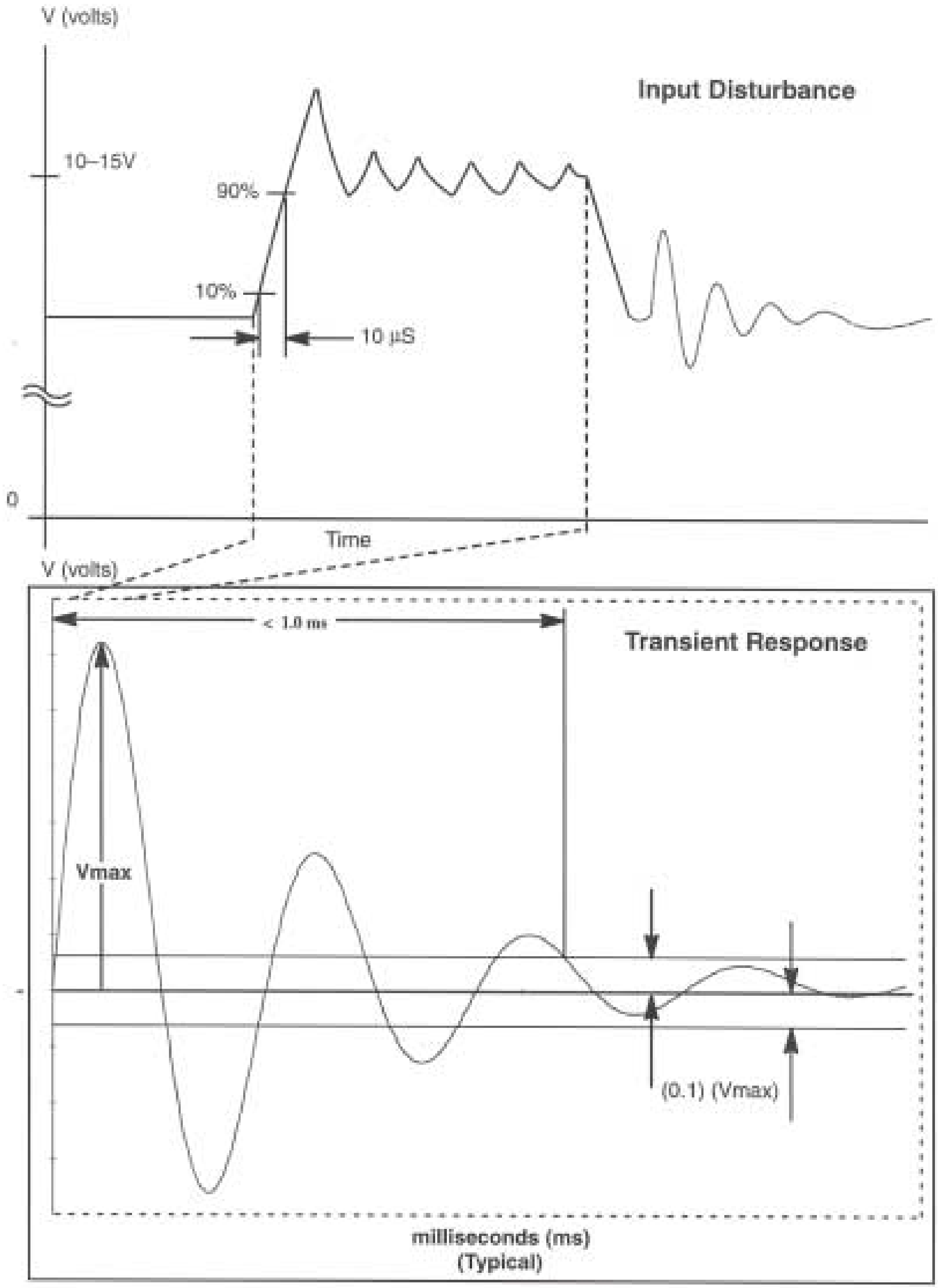


Figure 22. Pulse Applied to the 120 VDC Input of the EPCE for Large Signal Stability

3.2.3 Electrical Power Consumer Constraints

3.2.3.1 Wire Derating

Derating criteria for Investigation hardware at and downstream of the RPDA shall be per NASA Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA-92-038.

3.2.3.2 Loss of Power

Investigations shall fail safe in the event of total or partial loss of power regardless of the availability of back-up power in accordance with NSTS 1700.7, ISS Addendum. The NSTS 1700.7 ISS Loss of Power is addressed in the Safe Without Services section of NSTS 1700.7, ISS Addendum.

3.2.4 Electromagnetic Compatibility (EMC)

Investigation hardware shall meet the EMC requirements specified herein.

3.2.4.1 Electrical Grounding/Isolation

a. Investigation hardware connected to the RPDA power sources available in the WV shall be designed to prevent intentional electrical current from flowing in ground references except under fault conditions.

b. The electrical design shall be such that the electromagnetic environment due to grounding is not configuration dependent.

c. Equipment external electrical signal and power grounds shall be dc isolated from each other at the Orbital Replaceable Unit (ORU) level.

d. Each separately derived electrical power source shall be electrically connected to structure at no more than one point.

e. Analog and digital signal grounds external to a system, subsystem, or equipment shall be electrically isolated from each other at the ORU level. Grounding within electrical or electronic equipment is at the discretion of the designer as long as the external power and external signal return isolation requirements are met.

3.2.4.1.1 Electrical Power

For the purpose of this document when referring to primary power this is the MSG 120V interface and when referring to secondary it is the 28V, ±12V and 5V interfaces.

3.2.4.1.1.1 Primary and Secondary Electrical Power

a. The MSG primary and secondary electrical power systems are distributed single point grounded by ISS or MSG. The Investigation shall not ground the primary or secondary returns. Users of power shall be direct current (dc) isolated such that the primary electrical power ground configuration is not dependent on the presence or absence of flight elements, systems, subsystems, equipment, or users.
b. Primary and secondary electrical power shall be dc isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm, individually, when grounds are not terminated to chassis or structure.

3.2.4.1.1.2 Tertiary or Converted Electrical Power

a. When grounding tertiary or converted electrical power, Investigation hardware shall be single point grounded.

b. Tertiary or converted electrical power shall be dc isolated from chassis, structure, equipment conditioned power return/reference, and signal circuits by a minimum of 1 megohm, individually, when all grounds are not terminated to chassis or structure.

3.2.4.1.1.3 Control Power Bus Return

The dc power control bus shall be independent of the primary, secondary and tertiary electrical power and shall be referenced to the system reference at a single location.

3.2.4.1.1.4 Isolated Electrical Power Within Equipment

Within equipment, conditioned electrical power shall be dc isolated from chassis and structure except at no more than one electrically conductive common point. Where termination is desired, the equipment designer has the option of either bringing the single point reference external to the equipment for termination to the nearest structure ground or, of terminating the reference point to the chassis internal to the equipment; both methods may be used simultaneously.

3.2.4.1.1.5 Isolated Electrical Power Between Equipment

Where equipment further conditions and isolates electrical power, e.g., for external channel–to–channel isolation or external signal–to–signal isolation, each secondary conditioned power reference shall be treated individually in the same manner as in 3.2.4.1.1.4.

3.2.4.1.1.6 Load Conversion

Where load conversion is done to supply any form of conditioned power to several devices or functions, that conversion shall re–establish a single point reference for the serviced equipment or functions.

3.2.4.1.2 Returns

3.2.4.1.2.1 Signal Circuit Return Grounding

Signal circuit conductors shall be dc isolated from chassis, structure, and equipment conditioned power return/reference, by a minimum of 1 megohm, individually, when not terminated by the signal circuit's single point ground/reference. The 1 megohm requirement will be verified with only one termination lifted at a time. An exception to the 1 megohm requirement for balanced circuits is found in paragraph 3.2.4.1.2.6 An exception for RF signals on coaxial cable is found in paragraph 3.2.4.1.2.7. Under no circumstances shall separate flight elements, assembly elements, systems, subsystems, or equipment depend on other equipment for signal reference or signal return grounding unless they are also dependent upon the other equipment for power.

3.2.4.1.2.2 Alternating Current Power Return

A neutral return wire shall accompany the alternating current input wires to individual equipment loads in the distribution of power.

3.2.4.1.2.3 Analog, Differential Circuit Return

Each differential analog circuit shall employ a separate return.

3.2.4.1.2.4 Discrete Returns

Low–level discrete signals shall use individual returns.

3.2.4.1.2.5 Pulse or Clock Circuit Returns

All digital, pulse, or clock circuits that do not use fiber–optic cabling shall use individual returns.

3.2.4.1.2.6 Returns, Signals Below Four Megahertz

Signal circuits external to Investigation equipment with frequency content below four megahertz shall be balanced and shall be isolated from chassis, structure, and user–conditioned power return/reference by a minimum of 6,000 ohms, individually (i.e., measured per connection, pin, wire, etc.). Otherwise external signals shall be isolated through optical isolators, transformers, etc. All references for circuits with frequencies below 4 MHz shall be single point grounded to conductive structure. Shield connections shall be made to either connector shells or to connector pins that are grounded when mated. Shield treatment is specified in Section 3.2.4.3**.**

3.2.4.1.2.7 Signals Equal to and Above Four Megahertz

Signals circuits with frequency components equal to or above four megahertz shall use controlled impedance transmission and reception media such as shielded twisted 72–ohm cable, "twin–ax" cable, "tri–ax" cable, or "co–ax" cable. Circuits using "twin–ax" cable shall be balanced and referenced to primary structure at a single point. “Tri–ax” cable shall use the center and inner shield conductors for unbalanced transmission, referenced to primary structure at a single point with the outer shield multipoint grounded as an “overshield”. DC isolated, single–ended circuits coupled by coaxial cable with the shield terminated 360 degrees at each end and at available intermediate point, shall be permitted for signals with the lowest frequency component equal to or above 4 MHz.

3.2.4.2 Electrical Bonding

Investigation hardware connected to the RPDA power sources available in the WV shall be bonded such that maximum electrical fault currents can be conducted without creating a thermal or electrical hazard. Electrical bonds between all equipment shall be made to minimize differences in potential.

The material used in the MSG work volume is 7075 aluminum nickel struck. A bonding test shall be performed during integrated testing with the Engineering Unit.

3.2.4.2.1 Classes of Application

Where a single bond is used to serve two or more classes of application, the design shall conform to the more stringent requirement of bonding. Investigation hardware shall analyze the application of the bond under evaluation and shall apply the class of bond that meets the functional requirements of the device, equipment, structure or interface in question.

3.2.4.2.1.1 Class H Bonding (Shock Hazard)

Class H bonds shall be applied to electrical and electronic equipment, and elements or structure. Class H bonding applies to nonpermanent interfaces such as mobile interfaces or dc power sources.

3.2.4.2.1.1.1 Resistance

Conductive conduit carrying electrical wiring shall have a low resistance bond of less than 0.1 ohm to conducting structure at each termination and breakpoint. The bonding path may be through the equipment at which the conduit terminates.

3.2.4.2.1.1.2 Grounding

Exposed conducting frames or parts of electrical or electronic equipment shall have a low resistance bond of less than 0.1 ohm to conducting structure. If the equipment design includes a ground terminal or pin which is internally connected to exposed parts, a ground connection to the terminal or pin shall be provided.

3.2.4.2.1.2 Class R Bonding (High Frequency Potentials, Antenna’s)

A Class R bond shall be applied where electronic devices require a low noise, near equipotential environment, a minimum potential drop or where the bond is part of a safety mandated, high frequency (minimum delay time) function such as fault clearing in the presence of an IVA or EVA.

3.2.4.2.1.2.1 Impedance

All electrical and electronic units or components which use or produce electromagnetic energy shall be installed to provide a continuous low impedance path from the equipment enclosure to the conductive structure. The Investigation shall demonstrate by test or analysis that the proposed bonding method results in a dc resistance of less than 2.5 milliohms across each faying surface in the bond path from enclosure to structure and an impedance of less than 100 milliohms up to a frequency of 1 megahertz. The bond from the equipment enclosure to the mounting plate furnished with the equipment shall also comply with these requirements, except that a suitable ground strap may be used across any necessary vibration isolators or other environment isolators. The impedance of the ground strap (length to width ratio no greater than 5 to 1) is not included in this measurement but the impedance of the faying surface to mating surface of the strap is.

3.2.4.2.1.2.2 Nearby Conductors

All conducting items having any linear dimension of 30 centimeters (cm) or more installed within one–fourth of the wavelength of the highest operating frequency of wiring carrying signals with frequencies that exceed 10 MHz, such as transmitting or receiving antenna lead–ins, shall have a bond to structure at least every interval that is one–fourth the wavelength of the highest operating frequency. Direct metal–to–metal contact is preferred. If a jumper/strap is used, the jumper/strap shall comply with the requirements of Class R bonds.

3.2.4.2.1.3 Class S Bonding (Static Charge)

3.2.4.2.1.3.1 Conducting Structural Items

All isolated structural conducting items having an area greater than 100 square centimeters which carry fluids in motion, or otherwise are subject to frictional charging or plasma–induced current flow or charging, shall have a mechanically secure conducting connection to conductive structure. The resistance of the connection shall be less than 1 ohm.

3.2.4.2.1.3.2 Composite Materials

All composite structural materials which are subject to frictional charging or plasma–induced current flow or charging shall have a mechanically secure conductive connection to adjacent conductive structural items. The dc resistance between the composite material connection and the structure shall not exceed 1000 ohms.

3.2.4.2.1.3.3 Conductive Mechanical Subassemblies/Parts

All moving parts having a surface area greater than 100 square centimeters and which are subject to frictional charging (charging mechanism required), e.g., gears, cams, rotary joints, etc., shall be equipped with a charge bleed–off mechanism. This mechanism may take the form of bleed wire, wiper strap, conductive lubricant, etc. The bleed–off path shall not exceed 1000 ohms to conductive structure.

3.2.4.2.1.3.4 Pipe and Hose Bonding

All conductive pipes, tubes, and hoses that carry fluids shall have a mechanically secure conductive connection to conductive structure that shall measure 1 ohm or less. The pipe, tube, or hose installation shall not be the primary path for electrical power under normal or fault conditions. Nonconductive plumbing installations shall be designed so that the static voltage generated by fluid flow will not exceed 350 volts at any point outside the pipes, tubes, or hoses.

3.2.4.2.1.3.5 Traditionally Homogeneous Structural Materials

The traditionally homogeneous class of structural materials includes glass, quartz, surface coatings, polymers, plastics, etc. These materials cover a wide range of conductivities. In each case where Class S applies (in all cases where none of the other classifications applies), the bond methodology shall assure that no conductive surface area greater than 200 square cm is without a bond path from conductive layer to conductive structure. The bond resistance from the connection point to conductive structure shall be less than 1 ohm.

3.2.4.2.2 Selection of Materials

Materials and parts for electrical bonding shall be as specified herein. Materials specified in this document shall also be selected in accordance with Section 3.10.

3.2.4.2.3 Standard Parts

Standard parts (MS, AN, or JAN) that comply with the requirements of this document shall be used for electrical bonding wherever suitable for the purpose intended and shall be identified on drawings by part numbers. Commercial standard parts such as screws, bolts, washers, nuts, and cotter pins that comply with the requirements of this document shall be permitted for electrical bonding in place of standard parts (MS, AN, or JAN).

3.2.4.2.3.1 Jumpers/Straps

Bonding jumpers/straps shall be avoided whenever possible. Bonding jumpers/straps across movable vibration or thermal isolation joints shall meet the applicable bond class resistance/impedance requirements. Bonding jumpers/straps shall be kept short and direct and have a length–to–width ratio that does not exceed 5 to 1. Bonding designs that require more than two (2) standard bonding jumpers/straps in parallel shall require approval. Bonding designs that require more then one bonding jumpers/straps in series to provide the required overall length, shall not be permitted.

3.2.4.2.3.2 Hardware Usage

The hardware used shall permit the bond to meet performance requirements over the mission life in the specified environments. Hardware shall comply with the material requirements of the applicable specification. Any coatings requiring refurbishment or maintenance on orbit shall not be used on removable joints. Where the fasteners are used to join two conductive materials that have their surfaces passivated, the fasteners shall provide a penetration of the passivating coatings to meet Class S bonding requirements.

3.2.4.2.4 Methods of Bonding

CRES and titanium are acceptable material for metal–to–metal bonding. A jumper (fault current) / ground strap (Class R), which meets the requirements in Section 3.2.4.2.1.2, across a bond is acceptable as a redundant fault current path. When parallel fault current paths exist for Class R bonds, at least one path shall meet all requirements in Section 3.2.4.2.1.2 using CRES or titanium.

3.2.4.2.4.1 Bonding Installations

Bonding installations are considered to be permanent and inherently bonded when using metal–to–metal joints by welding, bolting, brazing, sweating, or swaging.

3.2.4.2.4.1.1 Semi–Permanent Bonding Applications

Examples of semi–permanent installations are the following:

- Bare metal–to–metal joints of machined surfaces held together by threaded locking devices and sealed
- Sealed metal–to–metal joints held together by a minimum of three threaded locking devices that penetrate insulating surface coatings
- Sealed riveted joints with a minimum of three rivets that penetrate insulating surface coatings. The use of this bond methodology requires analysis of metal relaxation effects on bond viability over the Station lifetime (Class S Bond Application only)
- Tie rods (Class S Bond Application Only)
- Structural wires under tension (Class S Bond Application Only)
- Bare metal–to–metal pinned fittings driven tight and sealed (Class S or H Bond Application only)
- Normally permanent and immovable clamp fittings which have been assembled after insulating finishes have been removed from the contact area and sealed after assembly (Class S Bond Application only).

3.2.4.2.4.2 Bonding Connections

Bonding connections shall be installed so that vibration, expansion, contraction, or relative movement incident to normal service use will not break or loosen the connection to such an extent that the resistance will vary during the movement. Bonding connections shall be located in a protected area, or accessible locations to permit rapid inspection or replacement The following conditions shall also apply:

- Equipment shall be bonded directly to the basic conducting structure or through permanently bonded parts. Bonding of overall shields to the connector backshell is the preferred method.

- Bonding jumpers shall be avoided whenever possible, but if they are utilized, they shall be installed so that movable components are not impeded in their operation by the jumper

- Bonding connections shall not be compression fastened through nonmetallic materials

3.2.4.2.4.3 Conductive Epoxy Resins

The use of conductive epoxy resins on equipment impractical to bond with preferred methods is permitted provided it conforms to the performance requirements of this document.

3.2.4.2.4.4 Tubular Structural Members

3.2.4.2.4.4.1 Conducting Material

Bonding of cylindrical or tubular conducting members not inherently bonded shall be accomplished by a plain clamp with a jumper or approved equivalents. The bond resistance should not be allowed to fluctuate as a result of thermal or mechanical stress and movement. Bonding clamps, when required on flexible metallic conduit or hose, shall be installed so as not to crimp or damage the conduit or hose.

3.2.4.2.4.4.2 Low–Conductivity Material

Low–conductivity materials shall be bonded to provide for static electrical discharges. The bonding resistance shall meet the Class S bond requirements.

3.2.4.2.4.5 Dissimilar Metals

When the joining of dissimilar metals cannot be avoided, the jumpers and other hardware used in the bonding connection shall be selected to minimize the possibility of corrosion. Washers shall not be surface treated or coated in any manner that will impair electrical conductivity. Unprotected, non–stainless steel shall not be used as a washer.

3.2.4.2.4.6 Refinishing

When it is necessary to remove any protective coating on metallic surfaces to conform with this requirements document, the completed assembly shall be refinished. Inspection shall be conducted after refinishing.

3.2.4.2.4.7 Intermittent Electrical Contact

Intermittent electrical contact between conducting surfaces shall be prevented either by bonding or by insulation if bonding is not necessary to conform to this requirements document.

3.2.4.2.4.8 Unapproved Bonding Methods

Antifriction bearings, wire–mesh vibration cushion mounts, or lubricated bushings shall not be used as a bonding path. Piano hinges shall not be used as a bonding path. Chemical conversion coatings shall not be used on internal removable bonding surfaces.

3.2.4.2.5 Bonding Faying Surface Preparation

3.2.4.2.5.1 Metal–to–Metal

Surface preparation for an electrical bond shall be accomplished by removing all anodic film, grease, paint, lacquer, or other high–resistance properties from the faying surfaces of the bond to ensure negligible impedance between adjacent metal parts. Abrasives which cause corrosion if embedded in the metal shall not be used. Abrasives or scrapers used to remove any protective finish shall produce a smooth surface without removing excessive material under the protective finish. Chemical cleaning and surface preparation shall be in accordance with the requirements of this document.

3.2.4.2.5.2 Nonmetal–to–Nonmetal

Surface preparation for an electrical bond shall be accomplished by removing protective films, grease, paint, lacquer, or other high–resistance properties from the immediate area to ensure a surface and contact resistance sufficient to meet the requirements of the applicable lower class of bonding. Abrasives or scrapers used to remove any protective finish shall produce a smooth surface without removing excessive material under the protective finish. Chemical cleaning and surface preparation shall be in accordance with the requirements of this document.

3.2.4.2.5.3 Metal–to–Nonmetal

Surface preparation for the metal member shall be as specified in 3.2.4.2.5.1 for metal–to–metal surfaces. Surface preparation for the nonmetal member shall be as specified in 3.2.4.2.5.2 for nonmetal–to–nonmetal surfaces.

3.2.4.2.6 Preparation of Electrical Mating Surfaces

The following procedures shall be used in the preparation of metals for electrical mating surfaces.

3.2.4.2.6.1 Nonconductive Films

Grease, oil, or other nonconductive films shall be removed with a cleaning agent which will remove the film without damaging the underlying metal or adjacent surfaces, including protective coatings.

3.2.4.2.6.2 Nonsoluble Films

Nonsoluble films shall be removed by sanding and polishing, using caution so as not to remove excessive metal. The area shall be cleaned.

3.2.4.2.6.3 Surface Treatment

After cleaning, the following substrate specific surface treatments shall be used:

3.2.4.2.6.3.1 Magnesium Alloys

Magnesium alloys shall not be used except in areas where minimal exposure to corrosive environments can be expected and protection systems can be maintained with ease and high reliability. Magnesium alloys shall not be used in the primary structure, or in other areas subject to wear, abuse, foreign object damage, abrasion, erosion, or at any location where fluids or moisture entrapment is possible. When used, magnesium alloys shall be treated as follows:

a. Wash the bare metal areas with a corrosion protection solution conforming to Type 1 of MIL–M–3171 for one minute and then thoroughly rinse with clean water within 5 seconds.

b. Dry thoroughly prior to organic finish repair, sealing, or assembly, as required to meet the performance requirements of 3.2.4.2.1.1, 3.2.4.2.1.2, or 3.2.4.2.1.3.

3.2.4.2.6.3.2 Aluminum Alloy

For nonremovable bonding surfaces, aluminum alloys shall be treated as follows:

a. After polishing mating surfaces, apply a chemical conversion coating conforming to Class 3 of MIL–C–5541.

b. Dry thoroughly prior to organic finish repair, sealing, or assembly, as required to meet the performance requirements of 3.2.4.2.1.1, 3.2.4.2.1.2, or 3.2.4.2.1.3.

c. For internal removable bonding surfaces, plated metallic finishes are required. Selective or capsule plating of nickel is preferred, with adequate corrosion protection provided to counteract the dissimilar metal couple created. Nickel plated aluminum is an acceptable substitute for meeting requirement.

3.2.4.2.7 Use of Sealant

For Class S bonds, the use of sealant which meets the requirements of material usage environments, such as BMS 10–79 and RTV–142, is acceptable for meeting the requirements in 3.2.4.2.6.3.2 (assuming the DC resistance value meets the requirement in 3.2.4.2.1.3.1).

3.2.4.3 Cable/Wire Design and Control Requirements

The following information is provided to the investigator for the reduction of electromagnetic effects in the wiring. This can be accomplished by isolating incompatible circuits via wire cable bundling, routing, shielding, separation, and wire treatment requirements presented herein.

3.2.4.3.1 Characteristics

3.2.4.3.1.1 Circuit Classification

The following criteria will be applied to determine the appropriate circuit classification for each circuit.

3.2.4.3.1.1.1 Frequency or Rise/Fall Time

For Table VIII, EMC Classification, Wire Type, and Shield Grounding classification purposes, the fundamental component of steady state operation will determine the frequency of the circuit unless the rise/fall time (pulsed wave forms) is less than 10 microseconds. If the rise/fall time is less than 10 microseconds and the voltage is less than 6 volts, the circuit shall be classified as Radio Frequency (RF) regardless of the fundamental frequency. Power circuits which are switched on and off will be classified as HO or EO even if their rise/fall times are less than 10 microseconds.

3.2.4.3.1.1.2 Impedance

The actual impedance of the interconnecting circuit, i.e., the complex “Z” that includes resistance, inductance and capacitance, will be used to classify the source and load impedances using Table VIII. These source and load impedances determine the magnetic and electric field coupling mode category. The equivalent circuit pickup resistance, i.e., the sum of the load and equivalent reactive/resistive components, will be used to identify potential areas for magnetic or electric field coupling.

3.2.4.3.1.1.3 Voltage

The maximum peak–to–peak voltage appearing at the source of each circuit will be used to determine the circuit classification using Table VIII.

3.2.4.3.1.1.4 Sensitivity

If the interface circuit is susceptible to magnetic or electric field coupling that can cause induced noise with amplitudes less than the source voltage that will affect measurement and/or conversion accuracy, circuit classification will be based upon circuit sensitivity considerations rather than upon frequency, rise/fall time, impedance, or voltage. Circuits assigned a classification based on sensitivity rather than on source voltage will be identified on all wiring diagrams containing such circuits.

3.2.4.3.1.1.5 Signal Type and Wire Type

Table VIII describes the classification of signal types and required wire type to control cable coupled interference. Cable and wire treatment will be based on Table VIII and the wire/cable and isolation requirements.

3.2.4.3.1.2 Classification/Wiring Procedure

The following requirements will be applied to determine the classification of wiring treatment and installation of all interface circuit types:

STEP 1. Circuit Classification

To determine the appropriate classification, the parameters of each subsystem equipment interface circuit will be considered in the following order: (1) frequency or rise/fall times, (2) impedance, (3) voltage, and (4) sensitivity. Classification criteria are specified in Table IX. This classification will appear on all wiring diagrams in which the circuit appears.

STEP 2. Determination of Interface Wiring Requirements

The appropriate wiring treatment will be assigned to each circuit as required by the classification considerations applied in STEP 1. The wire type, twisting, shielding, and shield grounding requirements will be reflected on all schematics, wiring diagrams, and Interface Control Documents in which the circuit appears.

STEP 3. Bundling of All Coded Circuits

Circuits having different circuit classifications or redundancy codes and routed in the same area will not be commonly bundled but may be routed in a common connector if a 20–dB coupling margin is maintained. Each bundle will be coded with a bundle code which is the same as the circuit classification of the circuits which it contains. Each bundle classification will be designated on drawings in which the bundle appears.

STEP 4. Redundancy Requirements

In cases where wiring redundancy is a requirement, separate cable bundles will be formed. Such bundles will be coded with the circuit classification code, plus a numeric designator code to identify the redundancy classification: ML–1, ML–2, EO–1, EO–2, etc.

STEP 5. Installation of Bundles

Cables, wires and cable/wire bundles will be locate and routed to provide a 20 dB cable to cable coupling loss using physical or electrical separation and considering the worst case steady state transient conditions. Minimum edge–to–edge bundle separation requirements (in inches) for parallel runs of L feet will be calculated. Separation requirements will be determined by redundancy requirements or calculations based on analysis of signal and power parameters, circuit sensitivities, wire/cable design, etc., whichever is greater.

3.2.4.3.1.2.1 Determination of Interface Wiring Requirements

The following criteria will be used to determine the wiring requirements for each circuit.

3.2.4.3.1.2.1.1 Wire Type

The categorization of each circuit in terms of frequency, impedance, voltage and/or sensitivity to assure proper EMEEC classification will permit the selection of wire type as specified in Table VIII. The wire types given in Table VIII are general in nature and do not alleviate the responsible design groups from specifying the wire size, allowable capacitance, and attenuation characteristics. Specific details on selected wire types will be included in applicable procurement specifications and assembly drawings.

3.2.4.3.1.2.1.2 Signal Types Requiring Controlled Impedance Characteristics

Serial digital, data bus, video, and clock circuits operating below 4 megahertz (MHz) will use controlled impedance wiring. RF circuits, including clock or data circuits with signal content of 4 MHz or above, will use fiber–optic, twinaxial or triaxial cable to maintain the requirements for isolation and single point references. Coaxial cable will be permitted for signals with frequency content above 4 MHz where dc isolation is maintained.

3.2.4.3.1.2.1.3 Shield Grounding Requirements

Shields shall be terminated at both ends and at intermediate break points directly to structure or chassis, through connector backshells or direct wire connection per the methodology specified in Section 3.2.4.3.1.2.4.

3.2.4.3.1.2.2 Implementation of Coding and Bundling

All circuits routed together in a bundle will be of the same classification. Circuits classified by sensitivity will be analyzed to determine if the source voltage will be detrimental to other circuits in the bundle and if it is necessary to isolate such circuit wiring from other wires in the classification.

3.2.4.3.1.2.3 Implementation of Bundle Installation

The bundles which have been formed and coded will be installed using the following requirements to provide the required electrical isolation between different signal levels.

3.2.4.3.1.2.3.1 Physical Isolation of Bundles With Different Codes

Each bundle type will be physically isolated from all other bundles of a different bundle code. This separation provides electromagnetic coupling isolation between unlike bundles and circuits carrying different redundancy codes.

3.2.4.3.1.2.3.2 Separation Requirements

Each bundle type of one code will be physically separated from other bundles to meet the 20–dB isolation requirement of Section 3.2.4.3.1.2. Metallic channel separation will be permitted in lieu of physical separation, provided that the channel separator height is no less than the largest cable bundle diameter requiring separation and that analysis shows that the channels provide the required 20–dB isolation. The application of such metallic barriers in lieu of physical separation will be identified on all wiring diagrams containing these circuits. Cable bundle placement in all wire trays will also be determined using minimum–to–maximum voltage or sensitivity requirements of Table VIII, e.g., EO and RF cable bundles will have maximum separation in the placement of adjacent wire bundles.

3.2.4.3.1.2.4 Shields

System interconnections shall terminate overall cable shields peripherally.

3.2.4.3.1.2.4.1 Terminations

Radio Frequency Interference (RFI) backshells with individual shield grounding provisions shall be used for multiple RF shield terminations. The length of the termination–to–ground lead for RF circuits shall be the minimum practical and shall not exceed 3 inches. The preferred method is to connect the shield peripherally to the backshell of an RF connector. This requires a continuous low–impedance electrical bond path through both halves of the connector shell, the connector–to–chassis interface, and the chassis–to–ground. All electrical connectors not engaged during mission shall be covered with a conductive cap. High impedance wires shall be terminated with a low impedance.

3.2.4.3.1.2.4.2 Breakouts

Where RFI backshells with individual shield grounding provisions are required for multiple shield terminations, RF circuit shields shall be broken out such that no more than 2 inches of wiring is exposed; and, the wiring must be contained within the connector metal backshell covering.

3.2.4.3.1.2.4.3 Grounding of Radio Frequency Circuit Shields

RF circuit shields shall be structure grounded as often as possible. This requirement can be satisfied by shield grounding to electrically conductive connector backshells at source and load and at any intermediate breakpoints.

3.2.4.3.1.2.4.4 Internal Equipment Shields

Shields originating and terminating within the same equipment shall be grounded therein.

3.2.4.3.1.2.4.5 Grounding

The shield ground shall be as specified in Table VIII.

Table VIII EMC Classification, Wire Type, and Shield Grounding

Frequency f: Rise, Fall Time (ms)t_r, t_f	Voltage or Sensitivity	Load Impedance (ohms)	Circuit Class	Minimum Wire Type	Shield Ground[1]
Analog (ac, dc) $f \leq 50$kHz $t_r, t_f > 10\mu s$	$\leq$100mV	<600 k	ML	TWS	MPG
	$\leq$100mV	$\geq$600 k	ML	TWDS	MPG
	<6V	All	ML	TWS	MPG
	6–40V	All	HO	TW	None
	>40V	All	EO	TW	None
50kHz>f $\leq$4MHz t_r, $t_f \leq 10\ \mu s$	<100mV	All	RF	TWDS	MPG
	>100mV	All	RF	TWS	MPG
f> 4MHz[1]	All	All	RF	TWS, Coax or Twin–ax	MPG
BWAD Fiber Optics	All	All	MO FO	TWS Fiber Optics	MPG

Acronyms and Abbreviations:		
	ML, HO, EO, MO FO	Arbitary Nomencalture to define circuit Classification
	MPG	Multiple Point Ground
	RF	Radio Frequency
	TW	Twisted
	TWDS	Twisted Double Shielded
	TWS	Twisted Shielded

Notes:

1. Shield grounding shall be compatible with the circuit application.
2. The length of termination–to–ground lead for all circuits shall be the minimum length practical.
3. The preferred method is to connect the shield peripherally to the back shell of the connector with a continuous impedance electrical bond path through both halves of the connector shell and the connector to mounting surface interface.
4. Digital signals shall be classified as RF (and routed as wire type called out in this table).

3.2.4.4 Electromagnetic Emission and Susceptibility Requirements

Investigation hardware emissions and susceptibilities shall comply with these requirements. Testing of the equipment to ensure compliance to the requirements of this document shall be performed using the test methods given in Appendix B.

Alternately, the investigation may choose to accept a minimal increase of EMI risk with a somewhat less stringent Electric Field Radiated Susceptibility (RS03) requirement on equipment considered to be non-safety critical to the vehicle and crew. The tailored RS03 requirement, shown below, will hereafter be denoted RS03PL.

FREQUENCY	RS03PL LIMIT (V/m)
14 kHz – 400 MHz	5
400 MHz – 450 MHz	30
450 MHz – 1 GHz	5
1 GHz – 5 GHz	25
5 GHz – 6 GHz	60
6 GHz – 10 GHz	20
13.7 GHz – 15.2 GHz	25

COMMENTS:
1. The less stringent RS03PL limit was developed to envelope the electric fields generated by ISS transmitters and ground-based radars tasked to perform space surveillance and tracking. Ground-based radars that are not tasked to track the ISS and search radars that could momentarily sweep over the ISS are not enveloped by the relaxed RS03PL. For most scientific payloads, the minimal increase of EMI risk for the reduced limits is acceptable. The RS03PL limit does not account for module electric field shielding effectiveness that could theoretically reduce the limits even more. Although shielding effectiveness exists, it is highly dependent on the EPCE location within the module with respect to ISS windows.
2. The conducted susceptibility requirements CS01, CS02 and CS06 are also used as the local stability requirements in Paragraph 3.2.2.9.

3.2.4.4.1 Self-Compatibility

The Equipment Under Test (EUT) shall not malfunction and performance shall not be degraded during Electromagnetic Interference (EMI) testing.

3.2.4.4.2 Equipment Emission and Susceptibility Limits

This paragraph defines emission and susceptibility test limits. General EMI test techniques are contained in Appendix B. Approval of design procedures and techniques does not relieve the Investigation of the responsibility of meeting the emission, and susceptibility test limits. A waiver is required for equipment which cannot meet the emission and susceptibility test requirements. The threshold of susceptibility shall be determined for equipment unable to meet the susceptibility test limits.

3.2.4.4.2.1 Conducted Emissions

Wiring between two or more Orbital Replacement Unit (ORU) shall be exempt from the conducted emission test requirements provided the specific ORUs are tested as a single unit. Wiring external to the group of ORUs tested as a unit shall meet the test limit requirements of this document.

3.2.4.4.2.1.1 CE01, Conducted Emissions

Direct current primary power (120V), low frequency, 30 hertz (Hz) to15 kilohertz (kHz). See 3.2.4.4.2.1.2.2 for details of direct current secondary power (28V, ±12V, 5V) frequency, 30 Hz to 50 MHz.

3.2.4.4.2.1.1.1 Applicability

CE01 is applicable only for narrowband emissions between 30 Hz and 15 kHz on the 120V primary.

3.2.4.4.2.1.1.2 CE01 Limits, 120V DC

Electromagnetic emissions shall not appear on dc leads in excess of the following values as shown below. The emission limit shown below is for equipment drawing one amp or less. For equipment drawing more than one amp, the limit, in decibels (dB) as shown in Table IX shall be raised by 20 x log I, where I equals the total dc current used by the equipment under test.

TABLE IX **CE01 Emission Limits**

120V Primary Power Source	
Frequency	Emissions
30 Hz-200 Hz	110 dB above 1 microampere (1)
200 Hz-15 kHz	Decreasing log-linearly with increasing frequency from 110 to 74 dB above 1 microampere (1)

(1) The emissions shall be measured with an effective bandwidth not exceeding 100 Hz.

3.2.4.4.2.1.2 CE03, Conducted Emissions

Direct current primary power (120V) leads, 15 kHz to 50 megahertz (MHz).
Direct current secondary power (28V, ±12V, 5V) frequency, 30 Hz to 50 MHz.

3.2.4.4.2.1.2.1 Applicability

CE03 is applicable only for narrowband emissions between 15 kHz and 50 MHz on the 120V primary; CE01/CE03 is applicable for narrowband emissions between 30 Hz and 50 MHz on the secondary on dc leads which obtain power from other sources or provide power to other equipment, distribution panels or subsystems.

3.2.4.4.2.1.2.2 CE03 Limits, 120V DC and CE01/CE03 Limits, +28V DC, ±12V DC and 5V DC

Electromagnetic emissions shall not appear on dc power leads in excess of the following values as shown below for narrowband emissions: The limit shown below is for equipment drawing one amp or less. For equipment drawing more than one amp, the limit as shown in Table X shall be raised by 20 x log I, where I equals the total dc current used by the equipment under test.

Table X CE03 Emission Limits 120V DC and CE01/CE03 Limits, +28V DC, ±12V DC and 5V DC

120V Primary Power Source CE03 Limits			
Frequency	Emissions		
15 kHz-500 kHz	Decreasing log-linearly with increasing frequency from 74 to 45 dB above 1 microampere		
500 kHz-50 MHz	45 dB above 1 microampere		
28V, ±12V, 5V Secondary Power Source CE01/CE03 Emission Limits			
Frequency	Conducted Ripple/RF Emissions dBµA per Ampere of Current Draw		
	28V	±12V	5V
30 Hz to 200 Hz	100		
200 Hz to 50 MHz	91		
30 Hz 1 k Hz		119	113
1 k Hz to 100 k Hz		99	93
100 k Hz to 50 M Hz		73	67

3.2.4.4.2.1.3 CE07, Conducted Emissions

Direct current power leads, spikes, time domain.

3.2.4.4.2.1.3.1 Applicability

CE07 is applicable for dc input power leads. Investigations using the MSG secondary power only are not required to perform this test.

3.2.4.4.2.1.3.2 CE07 Limits

CE07 on/off and mode switching transients shall not exceed the envelope defined by the following values listed in Table XI. Repetitive on/off and mode switching transients shall not occur more frequently than every 100 milliseconds.

Table XI CE07 Mode Switching Transients Envelope

Time (Micro-Seconds)	Percentage of Nominal Line Voltage
0.1-10	± 50 percent
10-50	Decreasing logñlinearly with increasing time from ± 50 percent to ± 20 percent
50-1000	Decreasing logñlinearly with increasing time from ± 20 percent to ± 5 percent or ± 6 volts(V), whichever is greater
1000-10,000	± 6 percent or ± 0.5V, whichever is greater
10,000-100,000	± 5 percent or ± 0.5V, whichever is greater

3.2.4.4.2.2 Conducted Susceptibility

3.2.4.4.2.2.1 CS01, Conducted Susceptibility

Direct current power leads, 30 Hz to 50 kHz.

3.2.4.4.2.2.1.1 Applicability

CS01 is applicable to equipment and subsystems using dc power.

3.2.4.4.2.2.1.2 CS01 Limits

The EUT shall not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to electromagnetic energy injected onto its power leads less than or equal to the values as shown in Table XII.

Table XII CS01 Electromagnetic Energy Injection

<table>
<tr><th colspan="4">120V Primary Power Source</th></tr>
<tr><td>Frequency</td><td colspan="3">Voltage</td></tr>
<tr><td>30 Hz-2 kHz</td><td colspan="3">5 V root mean square (rms) or 10 percent of the supply voltage (E1), whichever is less</td></tr>
<tr><td>2 kHz-50 kHz</td><td colspan="3">Decreasing log-linearly with increasing frequency from 5 Vrms or 10 percent of E1 whichever is less, to either 1 Vrms or 1 percent of the supply voltage, whichever is less</td></tr>
<tr><th colspan="4">28V, ±12V, 5V Secondary Power Source</th></tr>
<tr><td>Frequency</td><td colspan="3">Voltage</td></tr>
<tr><td></td><td>28V</td><td>±12V</td><td>5V</td></tr>
<tr><td>30 Hz to 50 kHz</td><td>0.5 Vrms</td><td>0.25 Vrms</td><td>0.25 Vrms</td></tr>
</table>

Alternate CS01 Limits for 120 volt loads:
The requirement is also met when the audio power source dissipates 50 W in a 0.5-ohm load, and cannot develop the required terminals, and the EUT is not susceptible to the output of the signal source.

Alternate CS01 Limits for 28 volt loads:
For 28 volt loads the requirement is also considered met at frequencies from 30 Hz to 50 kHz when the ripple source, limited to 50 watts into a 0.5 ohm load, cannot develop 0.5 volts rms at the test sample power input terminals and the test sample is not susceptible due to the output of the signal source.

Alternate CS01 Limits for ±12 and +5 Volt loads:
For ±12 volt and +5 volt loads the requirement is also considered met at frequencies from 30 Hz to 50 kHz when the ripple source, limited to 5 watts into a 0.5 ohm load, cannot develop 0.25 volts rms at the test sample power input terminals and the test sample is not susceptible due to the output of the signal source.

3.2.4.4.2.2.2 CS02, Conducted Susceptibility

Direct current power leads, 50 kHz to 50 MHz.

3.2.4.4.2.2.2.1 Applicability

CS02 is applicable between 50 kHz and 50 MHz for equipment and subsystem dc power leads, including power returns which are not grounded internally to the equipment or subsystem.

3.2.4.4.2.2.2.2 CS02 Limits

CS02 Limits, 120V DC:
The EUT shall not exhibit any malfunction, degradation of performance or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to 1 Vrms (for the 120V interface) from a 50-ohm source. The test signal shall be applied to the equipment power line near the equipment input terminals.

Alternate CS02 Limits for 120V loads:
The requirement is also met under the following condition: A 1 Watt source of 50-ohms impedance cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

CS02 Limits, +28V DC, ±12V DC and 5V DC:
Investigations using the secondary power interfaces shall meet this requirement, but use the injection voltage of 0.1 volts rms for the Secondary Power Source (28V, ±12V and 5V).

Alternate CS02 Limits for 28 Volt, ±12 Volt and +5 volt Loads:
For 28 volt, ±12 volt, and +5 volt loads the requirement is also considered met at frequencies from 50 kHz to 50 MHz when the ripple source, limited to 1 watt into a 50 ohm load, cannot develop 0.1 volts rms at the test sample power input terminals and the test sample is not susceptible due to the output of the signal source.

3.2.4.4.2.2.3 CS06, Conducted Susceptibility

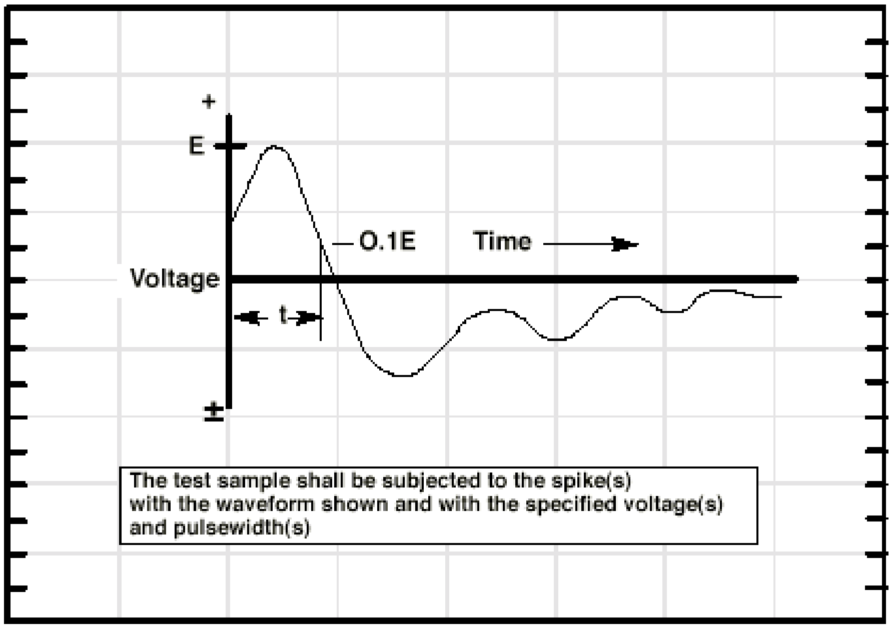
Spikes, power leads.

3.2.4.4.2.2.3.1 Applicability

CS06 is applicable to equipment and subsystem dc power leads, including grounds and returns which are not grounded internally to the equipment or subsystem. Investigations using the MSG secondary power only are not required to perform this test.

3.2.4.4.2.2.3.2 CS06 Limits

The EUT shall not exhibit any malfunction, degradation of performance or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when the test spikes, each having the waveform shown on Figure 23, are applied sequentially to the dc power input leads. The values of E and t are given below. Each spike shall be superimposed on the powerline voltage waveform.



SPIKE #1 E = ± Twice the nominal line voltage, t=10 microseconds ± 20 percent

SPIKE #2 E = ± Twice the nominal line voltage, t=0.15 microseconds ± 20 percent

Figure 23. <u>CS06 and RS02 Equipment Limit</u>

3.2.4.4.2.3 Radiated Emissions

3.2.4.4.2.3.1 RE02, Radiated Emissions

Electric field, 14 kHz to 10 GHz, 13.5-15.5 GHz (narrowband).

3.2.4.4.2.3.1.1 Applicability

RE02 is applicable for radiated emissions from equipment and subsystems, cables (including control, pulse, IF, power and antenna transmission lines) and interconnecting wiring of the test sample; for narrowband emissions, it applies at the fundamental frequencies and all spurious emissions including harmonics, but does not apply for radiation from antennas. This requirement is applicable for narrowband emissions from 14 kHz to 10 GHz and 13.5-15.5 GHz.

3.2.4.4.2.3.1.2 RE02 Limits

E-field emissions shall not be radiated in excess of those specified in the following paragraphs. Above 30 MHz, the limits shall be met for both horizontally and vertically polarized waves. Measurement shall be made in the peak detector mode.

3.2.4.4.2.3.1.2.1 Narrowband Electric Field Emissions

Narrowband Eñfield emissions shall not be radiated in excess of the values as shown in Table XIII and in Figure 24 at the required test distance of 1 m.

Table XIII Field Emission Limits

Frequency	Emissions
14 kHz-10 MHz	56 dBμV/m
10 MHz-259 MHz	Increasing logñlinearly with increasing frequency from 56 to 86 dBμV/m (16dB per decade)
259 MHz-10 GHz	Increasing logñlinearly with increasing frequency from 46 to 72 dBμV/m (16dB per decade)
13.5-15.5 GHz	76 dBμV/m

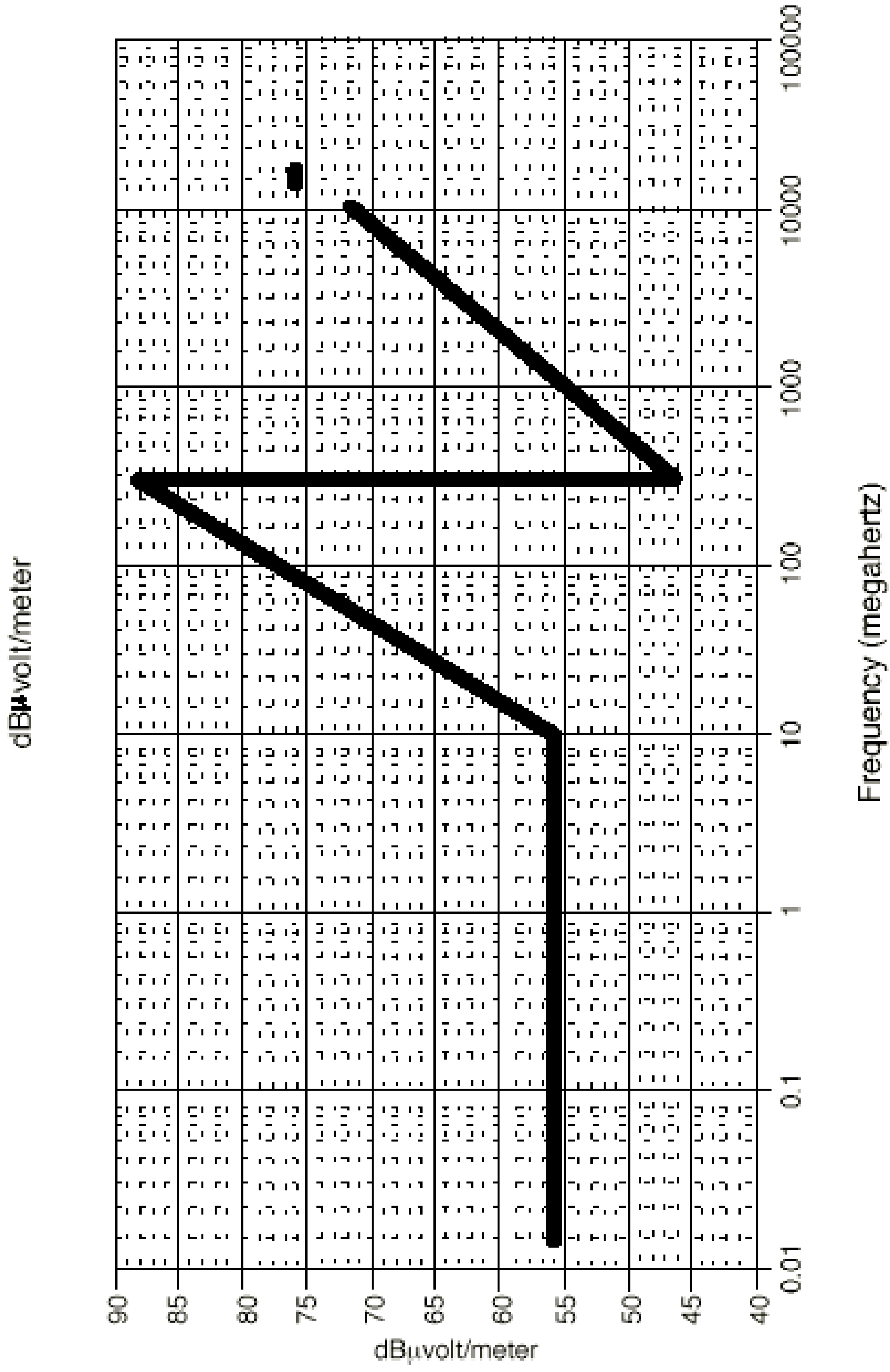


Figure 24. **<u>ISS Emission Limits</u>**

3.2.4.4.2.4 Radiated Susceptibility

3.2.4.4.2.4.1 RS02, Radiated Susceptibility

Magnetic induction field.

3.2.4.4.2.4.1.1 Applicability

RS02 is applicable for all equipment and subsystems. These susceptibility signals are electromagnetically coupled into the equipment or subsystem wiring.

3.2.4.4.2.4.1.2 RS02 Limits

The EUT shall not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected sequentially to the test spikes, shown in Figure 23, each having the waveform with the values of E and t are given below:

- Spike #1 E = ± Twice the nominal line voltage, t = 10 microseconds ± 20 percent
- Spike #2 E = ± Twice the nominal line voltage, t = 0.15 microseconds ± 20 percent.

3.2.4.4.2.4.2 RS03, Radiated Susceptibility

Electric field, 14 kHz to 20 GHz.

3.2.4.4.2.4.2.1 Applicability

RS03 is applicable for all equipment and subsystems between 14 kHz and 20 GHz. Above 10 GHz, this requirement applies only at specific frequencies and amplitudes known to be present at the Space Station. Below 10 GHz, this requirement shall be increased only at specific frequencies and amplitudes known to be present at the ISS. Module shielding effectiveness can be used to limit the levels applied.

3.2.4.4.2.4.2.2 RS03 Limits

The EUT shall not exhibit any malfunction, degradation of performance, or deviation, from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to the radiated electric fields less than or equal to those specified herein. Above 30 MHz, the requirement shall be met for both horizontally and vertically polarized waves. As a minimum, the levels shown in Table XIV apply at either the specific frequencies stated or across the ranges stated.

Table XIV RS03 Limit Levels

Frequency/Range	Radiated Electric Field Level
14 kHz-400 MHz	5 V/m
400 MHz-450 MHz	30 V/m
450 MHz -1 GHz	5 V/m
1 GHz - 5 GHz	25 V/m
5 GHz - 6 GHz	60 V/m
6 GHz - 10 GHz	20 V/m
13.7 GHz-15.2 GHz	25 V/m

3.2.4.4.2.5 Leakage Emissions

3.2.4.4.2.5.1 LE01, AC Power User Leakage Current

3.2.4.4.2.5.1.1 Applicability

LE01 is applicable for all equipment and subsystems that use ac power.

3.2.4.4.2.5.1.2 LE01 Limits

The leakage current for all equipment and subsystems using ac power, as measured between chassis and input power, at the power frequency, shall not exceed 5 milliamperes.

3.2.4.4.2.6 Testing Requirements

The test requirements and techniques of Appendix B shall be used to determine compliance with the applicable emission and susceptibility test limit requirements of this document. When an EUT susceptibility is noted, the thresholds of susceptibility shall be determined. Equipment that is intended to be operated as a subsystem shall be tested as such to the applicable emissionand susceptibility limits whenever practical.

3.2.4.5 Electrostatic Discharge

All unpowered Investigation equipment shall not be damaged by Electrostatic Discharge (ESD) equal to or less than 4,000 V to the case or any pin on external connectors. EPCE that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position. Handling of EPCE susceptible to ESD up to 15,000 V shall be in accordance with MIL-STD-1686. These voltages are the result of charges that may be accumulated and discharged from ground personnel or crewmembers during equipment installation or removal.

3.2.4.6 Alternating Current (AC) Magnetic Fields

Investigation generated ac magnetic fields, measured at a distance of 7 centimeters (cm) from the MSG work volume, shall not exceed 140 dB above 1 picotesla for frequencies ranging from 30 Hz, then falling 26.5 dB per decade to 3.5 kHz, and 85 dB for frequencies ranging from 3.5 kHz to 50 Khz.

3.2.4.7 Direct Current (DC) Magnetic Fields

Investigation components containing permanent magnet or electromagnetic devices shall not exceed 170 dB picotesla at a distance of 7 cm from the MSG work volume. This applies to electromagnetic and permanent magnetic devices.

3.2.4.8 Deleted

3.2.5 Payload Electrical Safety Requirements

3.2.5.1 Mating/Demating Of Powered Connectors

The Investigation shall meet the electrical safety requirements as defined in NSTS 1700.7B ISS Addendum. Payloads shall comply with the requirements for mating/demating of powered connectors specified in NSTS 18798, MA2-99-170. Investigation crew procedures shall direct the operator to interrupt power via the CMP prior to mating/demating of connecotors.

3.2.5.2 Safety-Critical Circuits Redundancy

Investigation EPCE shall meet the safety requirements as defined in NSTS 1700.7, ISS Addendum. The Investigation EPCE connected to a power source shall meet the safety critical circuits redundancy requirements defined in NSTS 18798.

3.2.5.3 Power Switches/Controls

The following power switches/controls requirements apply to power interfaces with open circuit voltage exceeding 30 volts rms or dc nominal (32 volts rms or dc maximum).

a. Switches/controls performing on/off power functions for an Investigation connected to any WV power interface shall open (dead-face), all supply circuit conductors except the power return and the equipment grounding conductor while in the power-off position.

b. Power-off markings and/or indications shall be used only if all parts, with the exception of overcurrent devices and associated EMI filters, are disconnected from the supply circuit.

c. Standby, charging, or other descriptive nomenclature shall be used to indicate that the supply circuit is not completely disconnected for this power condition.

3.2.5.4 Deleted

Table XV Let-go Current Profile Threshold Versus Frequency

Deleted

3.2.5.5 Deleted

3.3 Command and Data Handling Requirements

The MSG provides an Investigation with the ability to communicate with five different systems:

MSG C&DH Systems
1) The Rack Controller (RC) which is also called the Standard Payload Computer (SPLC)
2) Experiment Control Board (ECB)
3) The MSG Laptop Computer (MLC)
4) The Video Drawer (VD)
5) The ISS Payload Ethernet Hub Gateway (PEHG)

There are seven different interfaces (six hardware and one software) available to an Investigation. These interfaces are listed in Table XVI and shown in Figure 25.

Table XVI - C&DH Interfaces Available to Investigations

Interface	Type	System	Section
Direct Experiment	RS422	RC	3.3.1
Investigation I/O	Analog & Digital I/O	ECB	3.3.2
MLC Serial	RS232/RS422	MLC	3.3.3
MLC Ethernet	802.3, TCP/IP	MLC	3.3.4
MLC Software	Socket	MLC	3.3.5
ISS LAN1/LAN2	802.3 Ethernet	ISS	3.3.6
Video	Composite for down-linking, YC for recording	VD	3.3.7

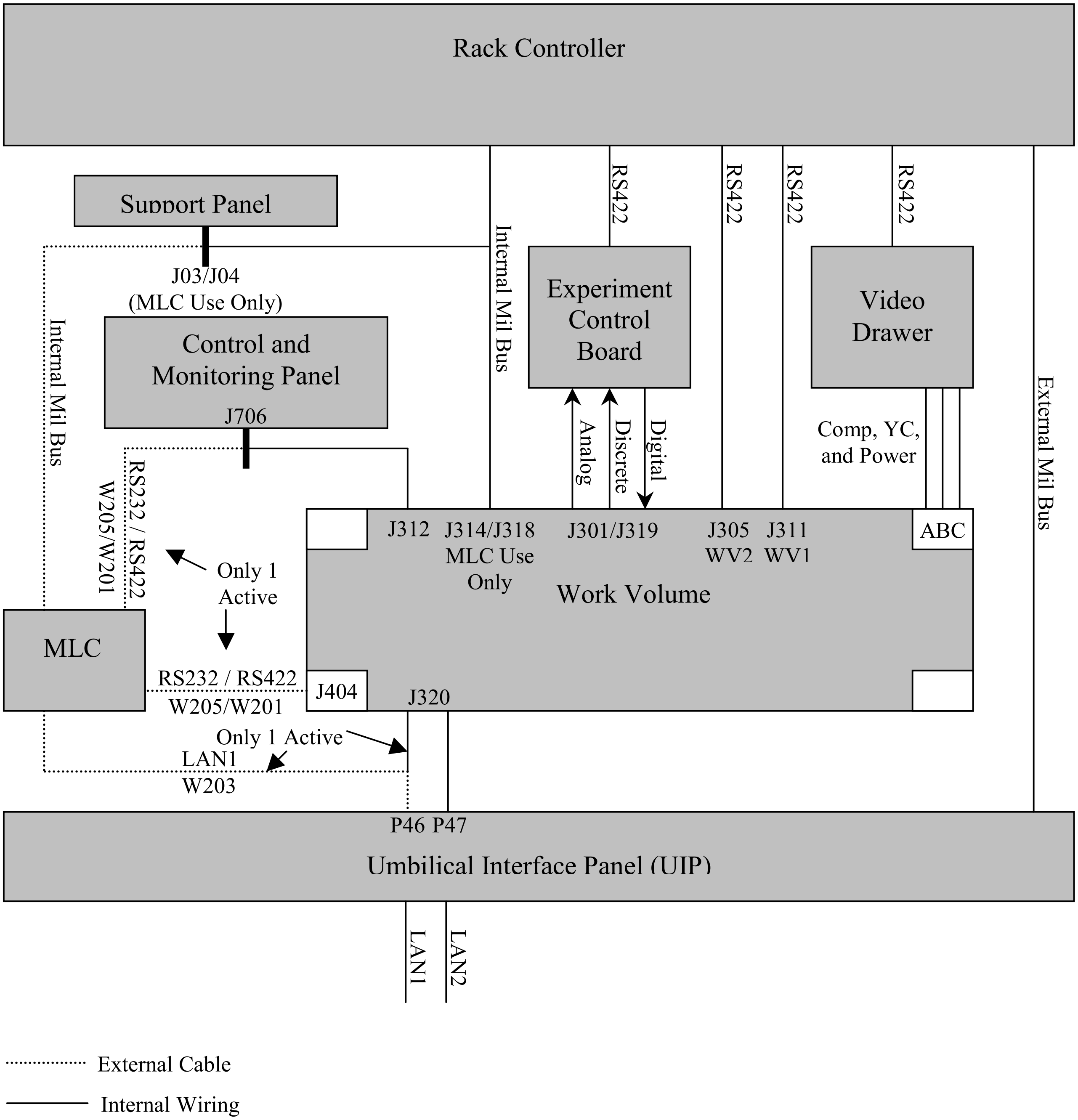


Figure 25. Data Handling System Block Diagram

Table XVII contains a list of C&DH related hardware that can be made available to an investigation.

Table XVII - C&DH Hardware Available to Investigations

Type	Hardware Description	P/N
Cable	W201 MLC with 232/422 converter	96M00557-01
Cable	W203 Ethernet P46 @ UIP	96M00559-01
Cable	W205 232 cable MLC	96M00561-01
Cable	W210 Ethernet P47 @ UIP	96M53046-01
Converter	RS422/232 Converter on W201 cable	96M53016-1
Feed-thru	J404 Feed-thru 232/422	96M53036-1
Feed-thru	J403 General Purpose Feed-thru (See note)	96M53037-1
PCMCIA	Micro Drive Assembly	96M53039-1
Cable	W208 LAN1 / LAN2 split cable for J320	96M53022-1
Cable	1553 Cable	96M53018-1

The J403 (connector type NB5H18-32PSN) is a straight pin-to-pin connector with 20 AWG pins, 32 available, and is user defined. Investigation provided connectors will be NB6E18-32PN when interfacing from inside the WV and NB6E18-32SN from the outside.

Detailed definitions of each C&DH interface are defined in MSFC-RQMT-3098, MSG-ORIGIN-IC-0001, SSP 57000, or SSP 52050. Verification items for each interface are outlined below. Appendix E of this document contains a Verification Data Sheet (VDS) for each section of each interface.

3.3.1 RS422 - Direct Experiment Interface

The RS422 - Direct Experiment Interface is an RS422 serial interface that allows an investigation to communicate directly with the Rack Controller (RC). There are two RS422 - Direct Experiment Interfaces in the Work Volume, designated WV1 and WV2.

3.3.1.1 RS422 Hardware Requirements

The hardware verification items for the RS422 - Direct Experiment Interface are contained in IIT-CD-01, Appendix E of this document.

3.3.1.1.1 RS422 Cable Characteristics

RS422 - Direct Experiment Interface wiring characteristics shall be in accordance with Table XVIII**.**

Table XVIII. RS-422 Direct Experiment Interface Cable Characteristics

Characteristic	**Parameter**
Type	Twisted Shielded Pair SSQ 21655 or Equivalent
Characteristic Impedance	100 ± 7 Ohm
Cable Size	22 AWG
Nominal wire-to-wire Capacitance	45 pf/m

3.3.1.1.2 WV RS-422 Direct Experiment Interface Connector/Pin Assignments

a. The WV RS422 – Direct Experiment Interface connectors (J305 and J311) are both type MS27656P9F35S, located on the WV rear wall as shown in Figure 2. The RS422 connection is a 4-wire point-to-point link of two users. The connector characteristics and pin assignments are shown in Tables XIX and XX.

b. The Investigation provided RS-422 connector (P305/P311) shall be of type MS27467T9F35P, and shall be compatible with the pin assignments shown in Tables XIX and XX.

Table XIX. WV1 RS-422 Connector J311 Contact Assignments

Connector Label: J311, WV RS-422	**Connector Type: MS27656P9F35S**		
Contact	**Contact AWG**	**Function/Description**	**Investigation Sends**
1	22D	RX+ RS-422 WV1	TX+
2	22D	RX- RS-422 WV1	TX-
3	22D	RX Shield RS-422 WV1	TX Shield
4	22D	TX+ RS-422 WV1	RX+
5	22D	TX- RS-422 WV1	RX-
6	22D	TX Shield RS-422 WV1	RX Shield

Table XX. WV2 RS-422 Connector J305 Contact Assignments

Connector Label: J305, WV RS-422	**Connector Type: MS27656P9F35S**		
Contact	**Contact AWG**	**Function/Description**	**Investigation Sends**
1	22D	RX+ RS-422 WV2	TX+
2	22D	RX- RS-422 WV2	TX-
3	22D	RX Shield RS-422 WV2	TX Shield
4	22D	TX+ RS-422 WV2	RX+
5	22D	TX- RS-422 WV2	RX-
6	22D	TX Shield RS-422 WV2	RX Shield

3.3.1.1.3 RS422 Signal Characteristics

Investigation hardware that requires connectivity to the RS422 - Direct Experiment Interface shall conform to the electrical characteristics specified in the Electrical Industry Standard RS422B specification.

3.3.1.1.4 RS422 Port Settings

Port settings for the RS422 - Direct Experiment Interface are fixed and are defined as follows:

Parameter	Setting
Baud	19200
Data Bits	8
Parity	None
Stop Bits	1

Investigations that interface to the RS422 - Direct Experiment Interface shall operate at these port settings.

3.3.1.2 RS422 Software Requirements

The software verification items for the RS422 - Direct Experiment Interface are contained in IIT-CD-02, Appendix E of this document.

3.3.1.2.1 RS422 Protocols

3.3.1.2.1.1 RS422 Byte and Bit Order

Investigation hardware that requires connectivity to a RS422 - Direct Experiment Interface shall conform to Section 1.4.3 Byte and Bit Order, of MSG-ORIGIN-IC-0001.

3.3.1.2.1.2 RS422 Word Alignment

Investigation hardware that requires connectivity to a RS422 - Direct Experiment Interface shall conform to Section 2.3 Word Alignment, of MSG-ORIGIN-IC-0001.

3.3.1.2.1.3 ESTEC Data Link Format (EDLF)

Investigation hardware that requires connectivity to a RS422 - Direct Experiment Interface shall conform to Section 3.5.1.1 ESTEC Data Link Format Description, of MSG-ORIGIN-IC-0001.

3.3.1.2.1.4 RC Required Headers

Investigation hardware that requires connectivity to a RS422 - Direct Experiment Interface shall conform to Section 3.1 External Interface Description (Block Definitions) & MSG Headers, of MSG-ORIGIN-IC-0001.

3.3.1.2.2 RS422 Message Types

Each RS422 – Direct Experiment Interface supports messages from the RC to the WV and messages from the WV to the RC.

RC To WV	WV to RC
Experiment Commands	Command Acknowledges
Time of Day (TOD) Data	Experiment H&S
File Transfers	Experiment LRT
	File Transfers
	Log Messages
	MSG Video Commands

3.3.1.2.2.1 RC to WV Messages

3.3.1.2.2.1.1 RS422 Experiment Commands

Experiment Commands transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.3 Experiment Commands, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.1.2 Time of Day (TOD) Data

Time of day data transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.6 TOD Data, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.1.3 RS422 File Transfers, RC to WV

Files transfers that are accomplished via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.4 of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2 WV to RC Messages

3.3.1.2.2.2.1 RS422 Command Acknowledges

Command Acknowledges transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.5 Command Acknowledges and Log Messages, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2.2 RS422 Experiment Health and Status

Experiment Health and Status data transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.2 Experiment Health and Status Data, of MSG-ORIGIN-IC-0001. The Health and Status Data an investigation is required to send is defined by the PSRP during the Safety Review process, see section 3.11 for additional information concerning Health and Status Data and Caution and Warning.

Safety data is included in the Experiment Health and Status data and shall conform to Section 3.1.5.7 Safety Data, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2.3 RS422 Experiment Low Rate Telemetry

Experiment Low Rate Telemetry data transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.1 Experiment Low Rate Telemetry Data, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2.4 RS422 File Transfers, WV to RC

Files transfers from the WV to the RC that are accomplished via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.4 File Transfers, WV to RC, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2.5 RS422 Log Messages

Log Messages transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.5.5 Command Acknowledges and Log Messages, of MSG-ORIGIN-IC-0001.

3.3.1.2.2.2.6 RS422 MSG Video Commands

MSG Video Commands transmitted via the RS422 - Direct Experiment Interface shall conform to Section 3.1.8, of MSG-ORIGIN-IC-0001.

3.3.2 Investigation I/O Interface

The MSG provides 8 analog inputs, 8 discrete inputs, and 8 digital outputs, split equally between two connectors in the Work Volume. When properly configured and enabled, the Experiment Control Board (ECB) reads the input lines and transmits the data to the RC. The RC in turn transmits the data to the ISS via the Low Rate Data Link (LRDL) in a Low Rate Telemetry (LRT) packet. The digital output lines are controlled via commands to the RC.

3.3.2.1 I/O Hardware Requirements

The hardware verification items for the Investigation I/O Interface are contained in IIT-CD-03, Appendix E of this document.

13.3.2.1.4 I/O Cable Characteristics

The Investigation I/O Interface wiring shall be 22 AWG TSP wire and all shields shall be tied to pin 9.

3.3.2.1.2 I/O Connector / Pin Assignments

a. The WV Investigation I/O connectors (J301/J319) are supplied on two MS27656P15F35SA connectors in the WV rear wall as shown in Figure 2. The connector characteristics and contact assignments are listed in Table XXI and XXII.

b. The Investigation provided connectors (P301/P319) shall be of type MS27467T15F35PA and shall be compatible with the contact assignments defined in Tables XXI and XXII.

Table XXI. WV I/O Connector J301 Contact Assignments

Connector Label: J301, Exp. Data 1	**Connector Type: MS27656P15F35SA**	
Contact	**Contact AWG**	**Function/Description**
1	22D	Exp. Data Analog in 0+
2	22D	Exp. Data Analog in 0-
3	22D	Exp. Data Analog in 1+
4	22D	Exp. Data Analog in 1-
5	22D	Exp. Data Analog in 2+
6	22D	Exp. Data Analog in 2-
7	22D	Exp. Data Analog in 3+
8	22D	Exp. Data Analog in 3-
9	22D	RTN Analog in (Contacts #1-8)
10	22D	Exp. Data Digital in 0
11	22D	Exp. Data Digital in 1
12	22D	Exp. Data Digital in 2
13	22D	Exp. Data Digital in 3
14	22D	Not Connected
15	22D	Not Connected
16	22D	Not Connected
17	22D	Not Connected
18	22D	RTN Digital in (Contacts #10-13)
19	22D	Exp. Data Digital out 0
20	22D	Exp. Data Digital out 1
21	22D	Exp. Data Digital out 2
22	22D	Exp. Data Digital out 3
23	22D	Not Connected
24	22D	Not Connected
25	22D	Not Connected
26	22D	Not Connected
27	22D	RTN Digital out (Contacts #19-22)
28	22D	Not Connected
29	22D	Not Connected
30	22D	Not Connected
31	22D	Not Connected
32	22D	Not Connected
33	22D	Not Connected
34	22D	Not Connected
35	22D	Not Connected
36	22D	Overall Shield (Contacts #9-13)
37	22D	Overall Shield (Contacts #18-22, 27)

Table XXII. WV I/O Connector J319 Contact Assignments

Connector Label: J319, Exp. Data 2	Connector Type: MS27656P15F35SA	
Contact #	**Contact AWG**	**Function/Description**
1	22D	Exp. Data Analog in 4+
2	22D	Exp. Data Analog in 4-
3	22D	Exp. Data Analog in 5+
4	22D	Exp. Data Analog in 5-
5	22D	Exp. Data Analog in 6+
6	22D	Exp. Data Analog in 6-
7	22D	Exp. Data Analog in 7+
8	22D	Exp. Data Analog in 7-
9	22D	RTN Analog in (Contacts #1-8)
10	22D	Exp. Data Digital in 4
11	22D	Exp. Data Digital in 5
12	22D	Exp. Data Digital in 6
13	22D	Exp. Data Digital in 7
14	22D	Not Connected
15	22D	Not Connected
16	22D	Not Connected
17	22D	Not Connected
18	22D	RTN Digital in (Contacts #10-13)
19	22D	Exp. Data Digital out 4
20	22D	Exp. Data Digital out 5
21	22D	Exp. Data Digital out 6
22	22D	Exp. Data Digital out 7
23	22D	Not Connected
24	22D	Not Connected
25	22D	Not Connected
26	22D	Not Connected
27	22D	RTN Digital out (Contact #19-22)
28	22D	Not Connected
29	22D	Not Connected
30	22D	Not Connected
31	22D	Not Connected
32	22D	Not Connected
33	22D	Not Connected
34	22D	Not Connected
35	22D	Not Connected
36	22D	Overall Shield (Contacts #9-13)
37	22D	Overall Shield (Contacts #18-22, 27)

3.3.2.1.3 I/O Signal Characteristics

Investigation hardware that requires connectivity to the Investigation I/O Interface shall conform to the electrical characteristics specified below:

- Analog Inputs (Investigation data) - differential, -9 to +9 V (read with 12 bits of resolution)

- Discrete Inputs (Investigation data) - single ended, 0-0.8 V for logical 0, 3.6-10 V for logical 1
- Digital Out (Investigation commanding) - single ended, 0-0.8 V for logical 0, 3.6-10 V for logical 1

3.3.2.2 I/O Software Requirements

There are no software verification items levied on an investigation for the Investigation I/O interface. However, there are software verification items to ensure that configuration and control commands are correct and that telemetry data can be correctly transmitted to the ground. The software verification items for the Investigation I/O Interface are contained in IIT-CD-04, Appendix E of this document.

3.3.2.2.1 I/O Experiment Telemetry

Details on the telemetry formats for the Investigation I/O Interface are found in 3.1.7.1 Experiment Telemetry Data of MSG-ORIGIN-IC-0001.

3.3.2.2.2 I/O Configuration and Control Commands

The Investigation I/O Interface configuration and control commands sent to the RC shall be in accordance with ECB 3.1.7.2 Configuration and Control commands of MSG-ORIGIN-IC-0001.

3.3.2.2.3 I/O Log Messages

The Investigation I/O interface will generate a log message when an error is detected. Log messages are defined in 3.1.16.1 Log Messages of MSG-ORIGIN-IC-0001.

3.3.3 MLC Serial Interface

The MLC provides a Serial Interface that is available to an investigation. The MLC Serial Interface is an EIA Standard RS232C asynchronous serial I/O port. Detailed specifications on RS232C can be found in EIA STD RS-232C.

3.3.3.1 MLC Serial Interface Hardware Requirements

The hardware verification items for the MLC Serial Interface are contained in IIT-CD-05, Appendix E of this document.

3.3.3.1.1 MLC Serial Interface Cable Characteristics

MLC Serial Interface wiring characteristics shall be in accordance with Table XXIII**.**

Table XXIII. MLC Serial Interface - RS 232C Cable Characteristics

Characteristic	**Parameter**
Type	Twisted Shielded Pair SSQ 21655 or Equivalent
Characteristic Impedance	100 ± 7 Ohm
Cable Size	22 AWG
Nominal wire-to-wire Capacitance	45 pf/m

3.3.3.1.2 MLC Serial Interface Connector / Pin Assignments

The MLC is typically located outside the work volume due to space limitations. However, it may be located inside, under special circumstances.

3.3.3.1.2.1 MLC Outside the Work Volume

When the MLC is to be used outside the work volume, the Investigation may connect to the J404 feed-through port in the front of the MSG WV, or to the J312 connector located on the WV rear wall. In either case, the Investigation provided connector (P404 or P312), shall be compatible with the connector and pin assignments identified in Table XXIV.

Table XXIV. Serial Connector Pin Assignments

Connector Label: J404, Serial RS232	**Connector Type: MS27656P9F35S**	
Contact	**Contact AWG**	**Function/Description**
1	20	RX+ (RS232 RX)
2	20	RX- (RS232 RTS)
3	20	RX Shield (RS232 GND)
4	20	TX+ (RS232 TX)
5	20	TX- (RS232 CTS)
6	20	TX Shield (RS232 GND)

J312 connector is identical to J404

The MSG provides two cables for use with MLC outside the work volume:

W201 - converts RS232 to RS422 signal levels (the converter is powered from the serial lines). This cable allows the MLC outside the work volume to communicate RS422 to an investigation inside the work volume. The investigation must provide a cable from the J404 or J312 connector to the experiment.

W205 - allows MLC outside the work volume to communicate RS232 to an investigation inside the work volume. The investigation must provide a cable from the J404 or J312 connector to the experiment.

3.3.3.1.2.2 MLC Inside the Work Volume

When the investigation is using the MLC inside the WV, the investigation may use the W201 or W205 cables provided by the MSG, or, the investigation may provide a cable that connects directly to the DB9 connector provided on the MLC. The investigation-supplied connectors shall be of type DB9 Female, and shall be compatible with the contact assignments defined in Table XXV.

Table XXV. DB9 Contact Assignments

Connector Label: MLC RS232	**Connector Type: DB9 Male**
Contact	**Function/Description**
1	Data Carrier Detect (DCD)
2	Receive Data (RD)
3	Transmit Data (TD)
4	Data Terminal Ready (DTR)
5	Signal Ground (SG)
6	Data Set Ready (DSR)
7	Request To Send (RTS)
8	Clear To Send (CTS)
9	Ring Indicator (Ring)

3.3.3.1.3 MLC Serial Interface Signal Characteristics

Investigation hardware that requires connectivity to the MLC Serial Interface shall meet the electrical characteristics in accordance with the Electrical Industry Standard RS232C specification.

3.3.3.1.4 MLC Serial Interface Port Settings

Investigations that interface to the MLC Serial Interface shall operate within the port settings defined in Table XXVI.

Table XXVI. MLC Serial Port Settings

Parameter	Setting
Baud	75, 110, 135, 150, 300, 600, 1200, 1800, 2400, 4800, 7200, 9600, 14400, 19200, 38400, or 57600
Data Bits	5, 6, 7 or 8
Parity	Even, Odd, Mark, Space, or None
Stop Bits	1, 1.5, 2
Flow Control	Hardware, Xon / Xoff, None

3.3.3.2 MLC Serial Interface Software Requirements

The MLC allows for an investigation to communicate directly to the MLC serial port, but strongly encourages investigations to use the MLC supplied server software. The MLC Server (MLCS) software allows an application to interface to the MLC Serial Interface without interfering with other MLC operations (see section 3.3.5 MLC Software Interface).

Investigations interfacing to the MLC Serial Interface via the MLCS shall conform to Section 4.6 Experiment Software Interfaces, of MSFC-RQMT-3098.

Investigations that use the MLC Serial Interface by means other than the MLCS shall coordinate with the IIT to obtain additional MLC software requirements and constraints.

The software verification items for the RS422 - Direct Experiment Interface are contained in IIT-CD-06, Appendix E of this document.

3.3.4 MLC Ethernet Interface

The MLC Ethernet Interface may be used for two purposes:
1) Transfer data directly to the ISS via the LAN1 MRDL
2) Data transfer from an investigation to MLC storage via FTP services (In order to utilize the FTP services of the laptop, the investigation must use a cross wired cable wired I.A.W. the IEEE 802.3.)

Investigations need to be aware that SAMS also uses Ethernet for rack-to-rack communications. If SAMS is required, LAN1 and LAN2 will not be available inside the work volume (LAN1 and LAN2 are both on the J320 connector, but the cable does not break out LAN1 for investigation use). In this scenario, LAN1 and LAN2 can be made available from outside the work volume through J46.

3.3.4.1 MLC Ethernet Interface Hardware Requirements

The hardware verification items for the MLC Ethernet Interface are contained in IIT-CD-07, Appendix E of this document.

3.3.4.1.1 MLC Ethernet Interface Cable Characteristics

The Investigation shall meet the cable characteristics given in Table XXVII.

Table XXVII. MLC Ethernet Cable Characteristics

Characteristic	Parameter
Characteristic Impedance	100 ±7 Ohm
Cable Size	22 AWG
Type of Cable	Twisted Shielded Pair SSQ 21655 or Equivalent
Nominal wire-to-wire Capacitance	45 pF/m
Max Cable Length	1.5 m

3.3.4.1.2 MLC Ethernet Interface Connector / Pin Assignments

In order to utilize the FTP services of the laptop, the experiment shall provide a cross wired cable that conforms to the IEEE 802.3 standards. Cables W208, W203, and W210 are provided by the MSG. These cables allow the MLC to communicate to the ISS LAN1 via the MRDL.

3.3.4.1.3 MLC Ethernet Interface Signal Characteristics

Investigations that require connectivity to MLC via the MLC Ethernet shall meet the electrical characteristics of Ethernet in accordance with ISO/IEC 8802–3 with the following exceptions:

IEC Publication 60 High-Voltage Test Techniques
IEC Publication 380 Safety of Electrically Energized Office Machines
IEC Publication 435 Safety of Data Processing Equipment
IEC Publication 950 Safety of Information Technology Equipment,
Including Electrical Business Equipment

3.3.4.2 MLC Ethernet Interface Software Requirements

Investigations communicating via the MLC Ethernet shall use the MLC Software Interface (see section 3.3.5) and shall conform to Section 4.6 Experiment Software Interfaces, of MSFC-RQMT-3098.

The hardware verification items for the MLC Ethernet Interface are contained in IIT-CD-08, Appendix E of this document.

3.3.5 MLC Software Interface

The MSG Laptop Computer (MLC) is an IBM Thinkpad 760XD model laptop computer. The MLC has a Pentium 166 MHz processor with 104MB of dynamic random access memory. A 6GB Hard Disk Drive is provided for use by the operating system, the MLC Server Software, Investigation Application Software, and for data storage. A 1.44 MB Floppy Disk Drive and a CD-ROM are provided as additional data storage devices.

The Microgravity Science Glovebox Laptop Computer Server (MLCS) is an application that executes on the MLC. The MLCS runs under the Windows NT 4.0 (service pack 5) operating system. The purpose of the MLCS is to abstract the input/output of the system when Experiment / Operations applications are running. The MLCS abstracts the 1553B interface to the Microgravity Science Glovebox Rack Controller, the Serial (RS232/RS422) connections to the experiments, the Medium Rate Data Link (Ethernet) interface to the International Space Station (ISS), and the Payload and General Support Computer's local hard disk drive. The MLCS will provide a consistent interface to each application and allow multiple applications to share information through the defined applications interface. The MLCS provides extensive ground commanding support (Timelines, Process Control, Aux Keyboard...) in an effort to reduce overall external support requirements. The interface requirements for the use of this software are documented in Software Requirements Specification for MSG Laptop Computer Server Software, MSFC-RQMT-3098. A Software Users Guide for MSG Laptop Computer Server Software, MSFC-HDBK-3168 is also available.

The verification items for the MLC Software Interface are contained in IIT-CD-9, Appendix E of this document.
The MLCS supports three interfaces to an investigation, RS232 Serial Port, Ethernet Port (FTP only), and Socket interface.

3.3.5.1 MLCS RS232 Interface

The MLCS provides software support for serial interfaces. The MLCS software supports the following baud rates: 57600, 38400, 19200 and 9600. The data format supported is 8 data bits, 1 start bit, 1 stop bit and no parity. The MLCS provides support for a RTS / CTS protocol, a dead band sync protocol, or the ESTEC Data Link Format (EDLF) protocol.

Data transfers utilizing the MLCS RS232 interface shall be compliant with Section 4.5.1 RS232 / RS422 Serial Interface, of MSFC-RQMT-3098.

3.3.5.2 MLCS Ethernet Interface

The MLCS provides FTP software support for the Ethernet interface via the Microsoft Internet Information Server (See section 3.3.5.3 MLCS Socket Interface, for MRDL software support). Investigations requiring FTP access to the MLC shall:

1) Interface to the MLCS via FTP at IP address 192.168.1.1, port 21 (standard FTP port)
2) Provide a cross wired cable wired I.A.W. the IEEE 802.3 (no Ethernet hub is provided).

Anonymous login is supported and the user is logged into C:\InetPub\ftproot directory with read/write privileges. Additional information is provided in Section 4.5.2 TCP/IP Ethernet Interface, of MSFC-RQMT-3098

Data transfers utilizing the MLCS Ethernet Interface shall be compliant with Section 4.5.2 TCP/IP Ethernet Interface, of MSFC-RQMT-3098.

3.3.5.3 MLCS Socket Interface

The MLCS provides applications software with interfaces to the MLC hardware and translation of the 1553 and MRDL interfaces. The interface requirements and a summary of the software interfaces of this software are documented in Section 4.6 Experiment Software Interfaces, of MSFC-RQMT-3098, Section 4.6.

3.3.6 ISS LAN1 / LAN2 Interface

The Investigation is provided a direct interface to the ISS LAN1 and LAN2 Ethernet via J320 on the WV rear wall. Investigations need to be aware that SAMS also uses Ethernet for rack-to-rack communications, and MSG does not provided an Ethernet Bridge so all Ethernet traffic will be seen at the interface. If SAMS is required, LAN1 and LAN2 will not be available inside the work volume (LAN1 and LAN2 are both on the J320 connector, but the cable does not break out LAN connections separately for investigation use). In this scenario, LAN1 and LAN2 can be made available from outside the work volume through J46.

It should be noted that Investigations within the MSG WV are also provided one Ethernet interface (LAN2), which is not supported by the MSG DHS, but instead is a direct connection to the ISS Ethernet.

3.3.6.1 Ethernet Interface Hardware Requirements

The hardware verification items for the Investigation Ethernet Interface are contained in IIT-CD-10, IIT-CD-11, and IITCD-12, Appendix E of this document.

3.3.6.1.1 Ethernet Interface Cable Characteristics

The Investigation shall meet the cable characteristics given in Table XXVIII.

Table XXVIII. Ethernet Cable Characteristics

Characteristic	Parameter
Characteristic Impedance	100 ±7 Ohm
Cable Size	22 AWG
Type of Cable	Twisted Shielded Pair SSQ 21655 or Equivalent
Nominal wire-to-wire Capacitance	45 pF/m
Max Cable Length	1.5 m

3.3.6.1.2 Ethernet Interface Connector / Pin Assignments

a. The WV Investigation Ethernet connector (J320) is supplied on a D38999/20FG75SN type connector on the WV rear wall as shown in Figure 2. The connector characteristics and contact assignments are defined in Tables XXIX.

b. The Investigation provided connector (P320) shall be of type D38999/26FG75PN and shall be compatible with the contact assignments defined in Tables XXIX.

Table XXIX. Ethernet Connector J320 Pin Assignments

Connector Label: J320, Ethernet		Connector Type: D38999/20FG75SN
Contact	**Contact AWG**	**Function/Description**
A-C1	Twinax	Ethernet 1 TX+
A-C2	Twinax	Ethernet 1 TX-
A-S	Twinax	Ethernet 1 Shield TX
B-C1	Twinax	Ethernet 1 RX+
B-C2	Twinax	Ethernet 1 RX-
B-S	Twinax	Ethernet 1 Shield RX
C-C1	Twinax	Ethernet 2 TX+
C-C2	Twinax	Ethernet 2 TX-
C-S	Twinax	Ethernet 2 Shield TX
D-C1	Twinax	Ethernet 2 RX+
D-C2	Twinax	Ethernet 2 RX-
D-S	Twinax	Ethernet 2 Shield RX

3.3.6.1.2 Ethernet Interface Signal Characteristics

Payloads that require connectivity to the Ethernet shall meet the electrical characteristics of Ethernet in accordance with ISO/IEC 8802–3 with the following exceptions:

IEC Publication 60 High-Voltage Test Techniques
IEC Publication 380 Safety of Electrically Energized Office Machines
IEC Publication 435 Safety of Data Processing Equipment
IEC Publication 950 Safety of Information Technology Equipment,
Including Electrical Business Equipment

3.3.6.1.3 Ethernet Interface Connectivity

Ethernet connectivity shall conform to section 3.3 MRDL, of SSP 52050.

3.3.6.2 Ethernet Interface Software Requirements

The software verification items for the Ethernet- Direct Experiment Interface are contained in IIT-CD-10 and IIT-CD-11, Appendix E of this document.

3.3.6.2.1 Ethernet Interface Protocol

Investigations that communicate via the Ethernet shall conform to Section 3.3, Medium Rate Data Link of SSP 52050.

a. Investigations that communicate via the Ethernet shall conform to ISO/IEC 8802–3 10–Base-T protocol in accordance with Section 3.3, Medium Rate Data Link (MRDL) of SSP 52050.

b. Investigations sending data to the ground through the USOS Space to Ground Link shall use the CCSDS protocol and gateway protocol in Section 3.3.4, Gateway Protocol and 3.3.7 Packet Length in SSP 52050.

3.3.6.2.2 Ethernet Interface Address

a. Investigations implementing Ethernet shall have a (unique) IEEE issued Ethernet Media Access Control (MAC) physical address (MAC Address), for each Ethernet attachment.

b. The MAC address shall be set prior to the Ethernet terminal going active.

3.3.7 Video Interface

A video system is provided in the MSG for investigation use. The entire system is described in the MSG Capabilities Manual, MSFC-HDBK-3051.

3.3.7.1 Video Interface Hardware Requirements

The hardware verification items for the Video Interface are contained in IIT-CD-13, Appendix E of this document.

3.3.7.1.1 Video Interface Cable Characteristics

Video cables shall be compatible with NTSC EIA RS170A standards.

3.3.7.1.2 Video Interface Connector / Pin Assignments

For Investigation provided cameras, MSG provides video/camera feed-through connectors on three separate ports located in the upper front left (3 connectors) and right (3 connectors) and bottom right (3 connectors) corners of the WV window.

The connector type for the feed-through connectors (A, B, C) are SGJ-2B-319-CLL-PV (LEMO), female contacts located on the WV inside. The investigation provided connector (A, B, C) shall be of type FGG-2B-319-CLCD and shall be compatible with the contact assignments defined in Table XXX when using the MSG video system. Connector markings and pin assignments shall be worked with the IIT and documented in the Unique Investigation ICD for the feed-through connectors.

Table XXX. Video Connector Contact Assignments

Connector Label: **A, B, C** **Exp. Video 1 – 9**	**Connector Type: LEMO: SGJ-2B-319-CLL-PV (LEMO)**	
Contact #	**Contact AWG**	**Function/Description**
1	22	RTN (power)
2	22	+ 12V In (power)
3	22	Not Connected
4	TSP	RTN Comp. video
5	TSP	Comp. video
6	TSP	RTN Y
7	TSP	Y Out
8	TSP	RTN C
9	TSP	C Out
10	TSP	RTN Sync
11	TSP	Sync. In
12	24	RTN 12V
13	24	Not Connected
14	24	SD In
15	24	SD Out
16	24	Not Connected
17	24	Not Connected
18	24	Not Connected
19	24	Not Connected

3.3.7.1.3 Video Interface Signal Characteristics

A 1A fuse with a de-rated current value of 0.65A protects the 12V power provided to the camera. The power consumption of an Investigation provided camera shall not exceed 7.8 Watts.

Investigation-provided cameras shall be National Television Standard Committee (NTSC) video standard EIA RS-170A cameras. The investigation will provide both Composite and YC signals to the 19-pin LEMO connector inside the Work Volume. The pinning of the interface cable to the feed-through depends on the video requirements and type of camera being used. The Composite video signal is required to view camera images on MSG monitors, and for video downlinking. The video recorders require the YC video signal.

3.3.7.2 Video Interface Software Requirements

There are no software verification items levied on an investigation for the Video Interface. However, there are software verification items to ensure that configuration and control commands are correct and can be successfully transmitted to the Video System. The software verification items for the Video Interface are contained in IIT-CD-14, Appendix E of this document.

3.3.7.2.1 Video Commands

Commands sent to the Video subsystem shall conform to Section 3.1.8.1 Video Commands, of MSG-ORIGIN-IC-0001.

3.3.7.2.2 Video Log Messages

The Video Interface will generate a log message when an error is detected. Video Log messages are defined in 3.1.8.2 Video Log Messages and Command Acknowledges Messages, of MSG-ORIGIN-IC-0001.

3.3.7.2.3 Video Health and Status

The MSG video system provides health and status information and is transmitted to the ISS in the MSG Health and Status packet. The video system health and status data is defined in 3.1.8.3 Video Health and Status of MSG-ORIGIN-IC-0001.

3.4 Thermal Control Interface Requirements

The MSG Thermal Control Subsystem (TCS) provides both water cooling and avionics air cooling for MSG and Investigation hardware. The paragraphs below define the interface characteristics for the MSG TCS interfaces that are provided to the Investigation within the WV.

3.4.1 Investigation Thermal Interfaces

Thermal cooling for Investigation hardware within the WV is provided by the WV Air Circulation System (ACS) and a coldplate which is mounted in the floor of the WV. Together, these provide a total 1,000 W of heat rejection for Investigation equipment inside the WV.

3.4.1.1 WV Air Circulation System (ACS)

The WV air circulation is established by the MSG Air Handling Unit (AHU). The AHU heat exchanger provides 200 W of investigation cooling, at an airflow rate of 1200 l/min and a maximum velocity of 0.044 m/s at the centerline of the WV. The airflow can be varied between 15% and 100% depending on fan speed settings. The rate and velocity is calculated without an Investigation inside the WV. Investigation power draw data shall be used to determine if the AHU heat exchanger is capable of removing the dissipated heat load.

The filtration system provides for particulate removal, filtration of single spillage (see section 3.7.3), and oxidation of CO to CO_2 by means of a built-in catalyst.

Due to the hydroscopic nature of the filters, the humidity inside the WV will be maintained at or below cabin level.

Figure 26 provides block diagram of the MSG air loops.

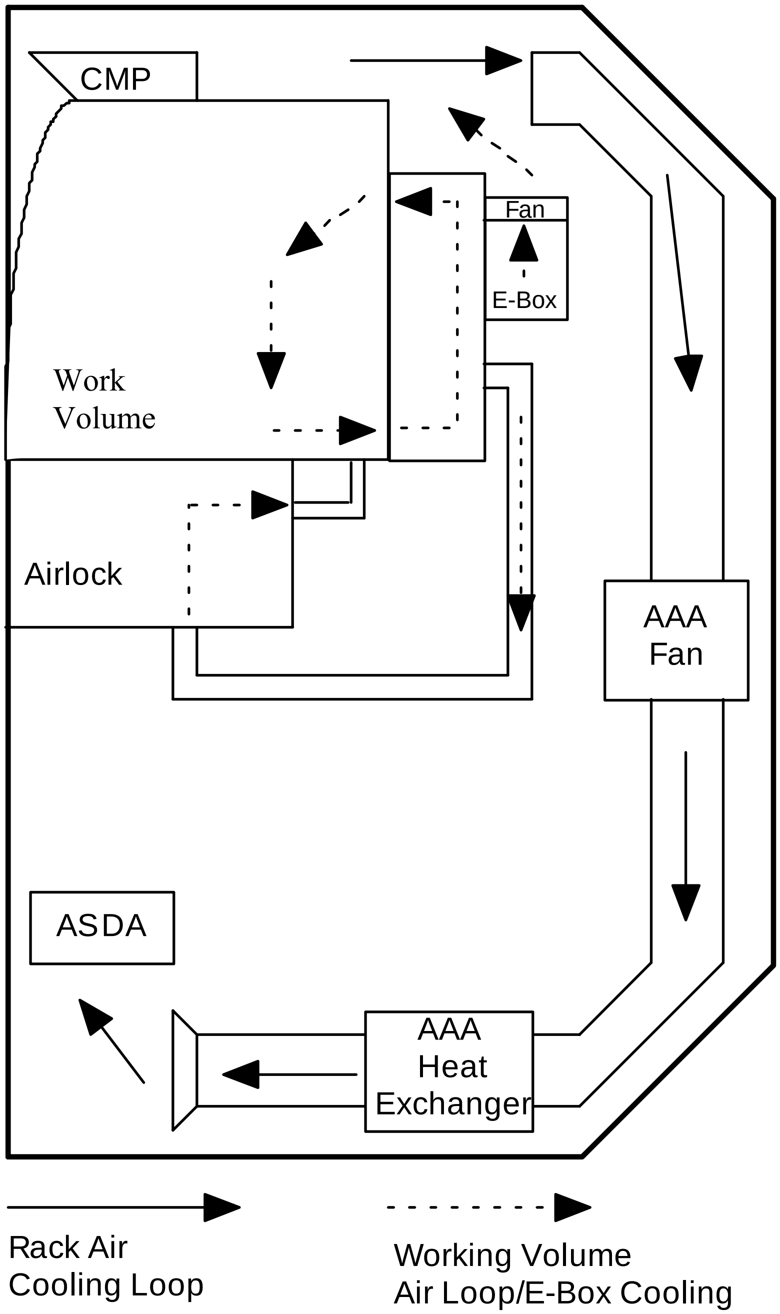


Figure 26. MSG Air Loops

3.4.1.2 WV Coldplate

Investigation cooling is also provided via a 350 mm x 400 mm coldplate embedded in the WV floor. Figure 29 provides a block diagram of the MSG water coolant loops.

The coldplate is located on the left side of the WV floor as indicated in Figure 2. Investigations that do not use the coldplate to dissipate heat are not required to meet the thermal requirements of section 3.4.1.2.1.

3.4.1.2.1 Investigation Coldplate Mounting Requirements

a. The Investigation baseplate shall maintain a flatness of less than 0.2mm and have a surface finish of 125 microinches on the surface in contact with the work volume coldplate.

b. The Investigation shall utilize M6 threaded captive fasteners to attach hardware to the work volume coldplate. Investigations using the coldplate to dissipate heat shall tighten their bolts in according with their thermal requirements but not to exceed 45 in-lbs of torque. If a special tool is required to torque the fasteners the Investigation shall provide it. Refer to Figure 2 for mounting hole locations.

c. The Investigation shall provide, to the maximum extent possible, an equal heat distribution over the coldplate surface.

d. Total heat dissipation to the coldplate shall be no more than 800 Watts.

The predicted MSG coldplate temperatures are shown in Figure 27 and Figure 28. These predicted coldplate temperatures are based on a MSG Rack coolant inlet temperature of 20 C. These temperatures are a function of experiment heat dissipation to the coldplate, experiment heat dissipation to Glovebox air, and coldplate coolant flow rate. Coolant flows to the MSG rack equipment, heat exchangers, and the MSG coldplate in series. The heat dissipation to Glovebox air and the heat dissipation of other rack equipment influence the temperature of the coolant at the inlet of the MSG coldplate and the coldplate temperature. Figure 27 is for a coolant flow rate of 45.4 kg/hr (100 lbm/hr) and is applicable to the majority of investigations that operate in the MSG. Figure 28 is for 200 watts to Glovebox air (a worst case scenario for coldplate temperatures) and allows for a coolant flow rate greater than 45.4 kg/hr (100 lbm/hr) for total internal MSG rack power that is greater than 900 watts.

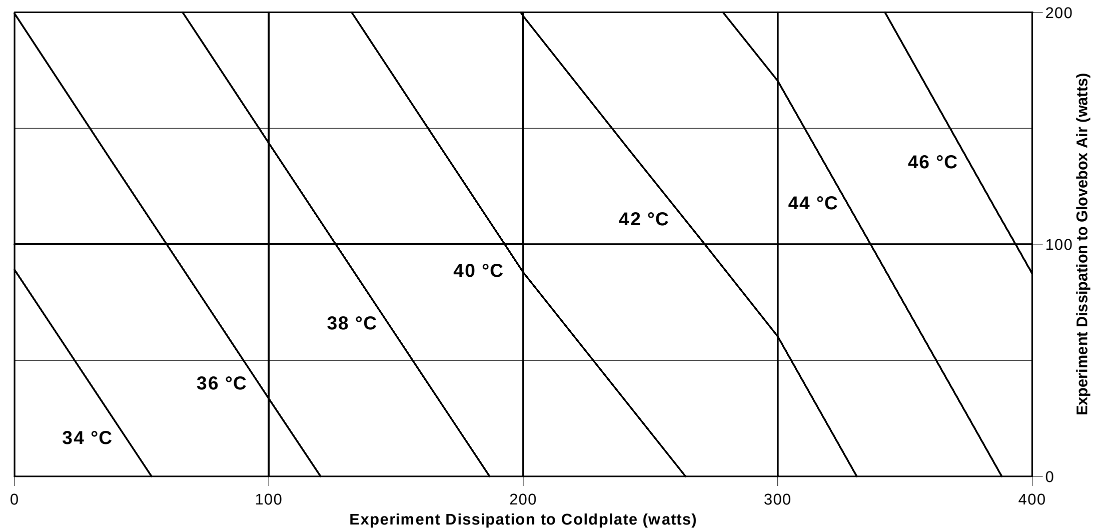


Figure 27. MSG Coldplate Temperature Contours for a Minimum Coolant Flow Rate of 45.4 Kg/hr

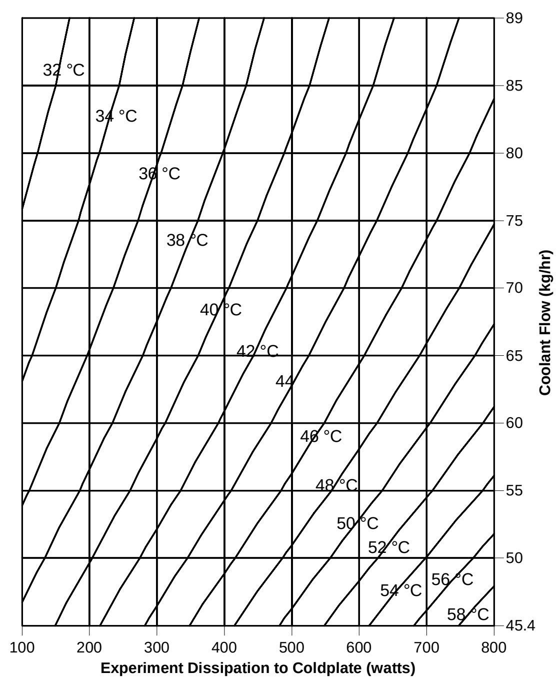


Figure 28. MSG Coldplate Temperature Contours for an Investigation with the Maximum Heat Dissipation of 200 Watts to Gloebox Air

3.4.1.3 Airlock Air Circulation System

No active thermal conditioning of the AL is provided. The AL ACS is part of the Glovebox ACS and provides conditioning of the AL atmosphere. Therefore, no powered operations will be conducted in the AL.
The AL airflow rate is 1 l/s with an air inlet area of 0.005 m^2. The fan speed can be adjusted at the CMP.

3.4.1.4 Loss of MSG Cooling or Services

Investigations shall be designed to maintain fault tolerance or safety margins consistent with the hazard potential, without ground or flight crew intervention, in the event of sudden loss or temporary interruption of the MSG coolant loop or the vacuum and nitrogen services in accordance with NSTS 1700.7, ISS Addendum.

Investigations that can not prove, by analysis, that loss of cooling does not produce a credible fire hazard, shall provide temperature sensors and parameters monitoring that will remove power from the payload in the case that the temperature goes above safe limits, see section 3.8.1.1, Investigation Monitoring and Detection.

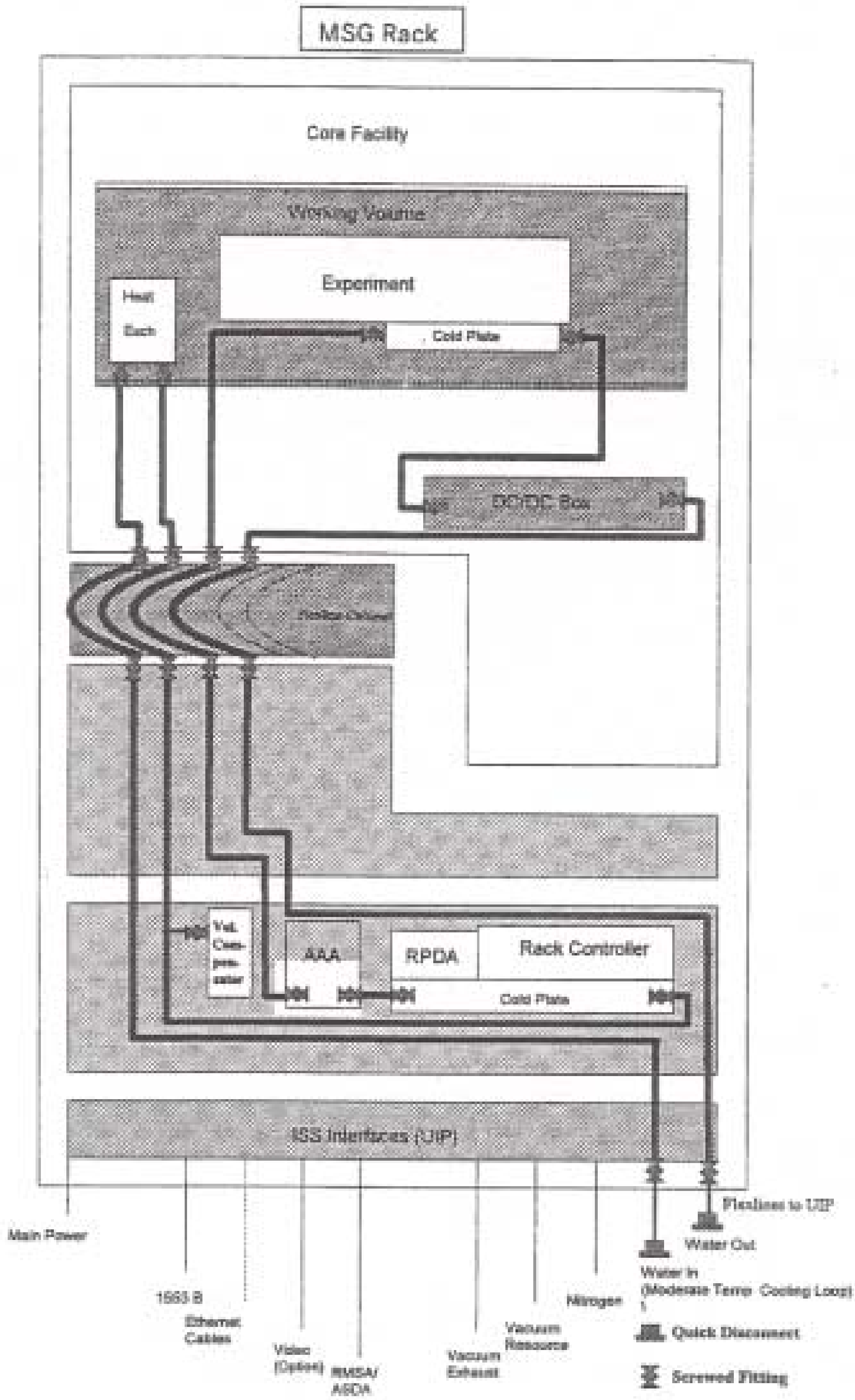


Figure 29. **MSG Water Loop**

3.5 Vacuum System Requirements

The MSG provides the Investigation a direct interface connection to the ISS Vacuum Exhaust System (VES) and Vacuum Resource System (VRS) via quick disconnects (QDs) and manual shut-off valves located on the rear wall of WV. The system becomes active after opening the shut-off valve inside the WV. Figure 30 provides a block diagram of the MSG to ISS Vacuum System interface.

3.5.1 Vacuum Exhaust System

3.5.1.1 VES Physical Interface

The WV VES QD is supplied on a 0.5" swagelock body, part # SS-QC8-B1-810K6, and white in color located on the WV rear wall as indicated in Figure 2.

a. The Investigation provided QD shall be a swagelock stem, part # SS-QC8-D1-810K6 and shall be compatible with the WV VES QD. In the part number the D indicates a double end shut-off and the K indicates the keying.

b. The maximum leak rate of the investigation volumes connected to the VES shall be 2 x 10^{-3} scc/sec.

c. The Investigation shall ensure that the VES manual shut-off valve will not be blocked during operations.

d. Gases released by the Investigation shall be within the same restrictions as for exhaust gases defined in section 3.5.1.5.

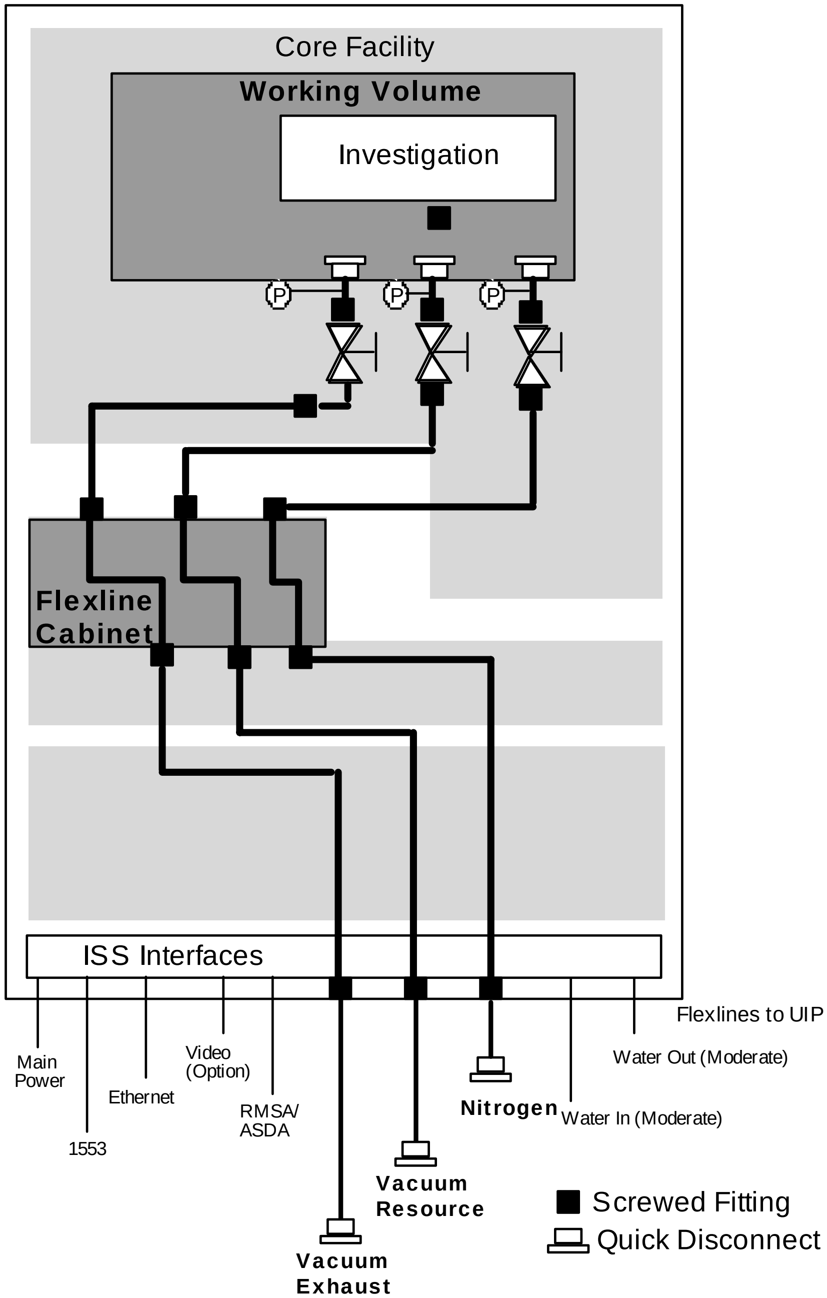
e. The Investigation shall incorporate into the crew procedures a procedure that directs the operator to monitor the pressure sensor between the manual shut-off valve and the QD to insure leak tightness of QD interface for each unique vacuum hose during the first connection to the VES.

3.5.1.2 Input Pressure Limit

a. Investigations shall limit their vented exhaust gas to a pressure of 276 kPa (40 psia) or less at the WV interface.

b. Investigation volumes connected to the VES shall be designed to the maximum design pressure (MDP) of at least 276 kPa (40 psia) with a safety factor of 1.5 based on MDP. Lines and fittings used to interface with the WV QD shall have an ultimate factor of safety equal to or greater than 4.0 based on MDP if the outside diameter < 1.5” and 2.0 if > 1.5”. Components connected to the VES shall have an ultimate of 2.5 based on MDP.

c. Investigations shall protect against failure conditions which would exceed the VES max design pressure of 276 kPa (40 psia).



Note: Pressure Transducers are for facility check out only.

Figure 30. MSG to ISS Vacuum System Interface

3.5.1.3 Input Temperature Limit

The initial temperature range of Investigation exhaust gases shall be between 16°C (60° F) and 45°C (113° F).

3.5.1.4 Input Dewpoint Limit

The initial dewpoint of Investigation exhaust gases shall be limited to 16° C (60° F) or less.

3.5.1.5 Acceptable Exhaust Gases

a. Investigation exhaust gases vented into the VES shall be compatible with the wetted surface materials of the U.S. Lab. Materials in the wetted surfaces of the U.S. Lab which will be in contact with user payload waste gases are limited to:

- Stainless steel 321 and 450,
- Titanium 6A1-4V,
- Fluorocarbon rubber (Viton) (in Pirani gage transducer),
- Glass,
- Platinum-iridium alloy,
- Gold plated brass (in cold cathode transducer),
- Ceramic,
- Aluminum, (in cold cathode transducer)
- Tetrafluoreothylene, (Teflon)

Note: The Investigation is responsible for providing containment, storage, and transport hardware for gases that are incompatible with the vacuum exhaust or external environment. Where applicable, containment hardware for incompatible gases must meet the redundant container requirements specified in, NSTS 1700.7, ISS Addendum, section 209.1b .

b. Investigation vented exhaust gases shall be non-reactive with other vent gas mixture constituents.

c. Investigations venting to the VES or VRS shall provide a means of removing gases that would adhere to the tubing walls at a wall temperature of 4° C (40° F) and at a pressure of 10^{-3} torr.

d. Investigations venting to the VES or VRS shall remove particulates from the vent gases that are larger than 100 micrometers in size.

3.5.1.5.1 Acceptable Gases-Initial List

A list of acceptable exhaust gases with verified compatibility to the U.S. Lab wetted materials is specified in Appendix D. A list of unacceptable gases that are not compatible with the U.S. Lab wetted materials is specified in Appendix D.

3.5.1.5.2 External Contamination Control

Investigation exhaust gases shall be compatible with the molecular column density, particulate, and deposition on external Space Station surfaces.

a. The molecular column density created by the presence of ISS contamination sources along any unobstructed line of sight shall not exceed $1x10^{14}$ molecular-cm $^{-2}$ for individual released species.

b. The release of particulates from the ISS shall be limited to one particle 100 microns or larger per orbit per $1x10^{-5}$ steradian field of view as seen by a 1 meter diameter aperture telecsope.

c. The flux of molecules emanating from the ISS shall be limited such that the 300K mass deposition rate on sampling surfaces shall be limited to $1x10^{-14}$ $g\text{-}cm^{-2}\text{-}sec^{-1}$ (daily average).

d. Investigations shall specify the material(s) to be dumped through the vacuum line.

e. Investigations shall provide an absorbing filter for toxic materials that are dumped through the VES.

3.5.1.5.3 Incompatible Gases

Deleted

3.5.2 Vacuum Resource System

3.5.2.1 VRS Physical Interface

The WV Investigation VRS QD is supplied on a 0.5" swagelock body, part # SS-QC8-B1-810K1, and black in color located on the WV rear wall as indicated in Figure 2.

a. The Investigation provided QD shall be a swagelock stem, part # SS-QC8-D1-810K1 and shall be compatible with the WV VRS QD. In the part number the D indicates a double end shut-off and the K indicates the keying.

b. The maximum leak rate of the investigation volumes connected to the VRS shall be 2×10^{-3} scc/sec.

c. The Investigation shall ensure that the VRS manual shut-off valve will not be blocked during experiment operations.

d. Gases released by the Investigation shall be within the same restrictions as for exhaust gases defined in section 3.5.1.5.

e. The Investigation shall incorporate into the crew procedures a procedure that directs the operator to monitor the pressure sensor between the manual shut-off valve and the QD to insure leak tightness of QD interface for each unique vacuum hose during the first connection to the VRS.

3.5.2.2 Input Pressure Limit

a. Investigations shall limit their vented VRS gas to a pressure of 10^{-3} torr or less at the WV interface.

b. Investigation volumes connected to the VRS shall be designed to the maximum design pressure (MDP) of at least 276 kPa (40 psia) with a safety factor of 1.5 based on MDP. Lines and fittings used to interface with the WV QD shall have an ultimate factor of safety equal to or greater than 4.0 based on MDP if the outside diameter < 1.5" and 2.0 if > 1.5". Components connected to the VES shall have an ultimate of 2.5 based on MDP.

c. Investigations shall protect against failure conditions which would exceed the VRS max design pressure of 276 kPa (40 psia).

3.5.2.3 VRS Through-Put Limit

The Investigation shall limit the gas throughput to the VRS to less than 1.2 x 10^{-3} scc/second.

3.6 Pressurized Gas Requirements

3.6.1 Nitrogen Interface Requirements

The MSG provides the Investigation a direct interface connection to the ISS Nitrogen via a quick disconnect (QD), and a needle valve located on the rear wall of WV. The system becomes active after opening the needle valve close to the CD. The MSG to ISS nitrogen interface is shown in Figure 30.

3.6.1.1 Nitrogen Physical Interface

The WV Investigation nitrogen QD is supplied on a 0.25" swagelock body, part # SS-QC4-B1-400, no key, and no color, located on the WV rear wall as shown in Figure 2.

a. The Investigation provided nitrogen QD shall be a swagelock stem, part # SS-QC4-D1-400 and shall be compatible with the WV GN_2 QD. In the part number the D indicates a double end shut-off.

b. The maximum leak rate of the nitrogen connection and any permeation through materials from the WV QD to the Investigation shall be no greater than 10^{-3} scc/sec at MDP. All Nitrogen flowing past the GN_2 valve is considered usage. The investigation allocation for GN_2 will comprise leakage and usage.

3.6.1.2 Nitrogen Flow Control

The MSG facility provides an orifice to control the flow of nitrogen so it does not exceed the ISS requirement of 5.43 kg/hr (12 lbm/hr) at an operating pressure of 517 to 827 kPa (75 to 120 psia) Investigations will provide their own means of controlling the flow of nitrogen if required.

3.6.1.3 Nitrogen Interface Design Pressure

The maximum design pressure (MDP) of the Investigation nitrogen system shall be 1,379 kPa (200 psia). Investigation volumes connected to the nitrogen system shall be designed with a safety factor of 1.5 based on MDP. Lines and fittings used to interface with the WV QD shall have an ultimate factor of safety equal to or greater than 4.0 based on MDP if the outside diameter < 1.5” and 2.0 if > 1.5”. Components connected to the nitrogen system shall have an ultimate of 2.5 based on MDP.

3.6.1.4 Nitrogen Interface Temperature

The Investigation nitrogen system will be designed for a nitrogen supply temperature range of 15.6 °C to 45 °C (60 °F to 113 °F).

3.6.1.5 Nitrogen Operational Constraints

Investigations using the nitrogen system shall incorporate the following controls into their procedures:

a. Oxygen sensor, provided by the investigation.

b. The crew is required to open a side port or front gloveport while fans are in Normal Mode so fresh cabin air can be sucked into the WV, filtered, and released. Investigation crew procedures shall direct the operator to purge the WV for two minutes prior to egress.

c. Verify reading of oxygen sensor is above 10.5% O_2 before opening the WV.

d. Investigation crew procedures shall direct the operator to close the needle valve prior to QD mate/demate. Crew procedures to direct operator to monitor the pressure sensor between manual shut-off valve and QD to insure leak tightness of QD interface for each unique nitrogen hose during the first connection to the nitrogen system.

3.6.2 Pressurized Gas Bottles

Pressurized gas systems with a total expanded gas volume exceeding 400 liters at standard conditions shall limit the gas flow after a single failure to less than 240 standard liter per minute after 400 liters at standard conditions has been released to the cabin air.

3.7 Environment Interface Requirements

3.7.1 Atmosphere Requirements

3.7.1.1 Pressure

The Investigation shall be safe when exposed to the pressure transitions between 0 to 104.8 kPa (0 to 15.2 psia).

3.7.1.2 Temperature

The Investigation shall be safe when exposed to the temperatures of 10 to 46° C (50 to 115° F). Investigation must be safe for all potential temperature conditions related from failures to ISS, MSG, or investigation hardware.

3.7.1.3 Humidity

The Investigation shall be designed to not cause condensation when exposed to a dewpoint of 4.5 to 15.6° C (40 to 60° F) and a relative humidity of 25 to 75% except when condensation is an intended operation of the Investigation.

3.7.2 Illumination

3.7.2.1 WV Illumination

An illumination system of three identical illumination units is accommodated in the WV top wall. The illumination system provides up to 1000 lux illumination at approximately 200 mm above the WV floor. The general illumination is variable in intensity. At the maximum intensity the color temperature is $\geq$ 2750° Kelvin, with a color rendering index (RA) of 85 or better.

If the Investigation requires additional lighting, a MSG provided spotlight can be used or the Investigation can provide its own dedicated illumination source provided it meets the requirements specified in paragraph 3.7.2.3.

3.7.2.2 Airlock Illumination

An illuminations system is accommodated inside the Airlock (AL) at the left wall which supplies 323 lux general working light. Switching the airlock illumination ON or OFF can be done by a switch on the CMP. There are no requirements to the Investigation concerning AL illumination.

3.7.2.3 Spotlight Illumination

MSG provides a spotlight, variable in intensity of up to 1000 lux at a spot diameter of 140 cm. The spotlight connector can be installed directly on the J304 connector on the rear wall of the WV, or if the ICP is connected, on the J334 connector. Both connector types are MS27656P15F35S. If the MSG spotlight does not meet the needs of the Investigation, a dedicated Investigation spotlight can be installed, provided it meets the requirements specified in paragraph 3.7.2.3.1.

3.7.2.3.1 ICP Outlet Interface Requirements

The WV ICP (J304) connector located on the WV rear wall and the ICP OUTLET (J334) connector located on the ICP are MS27656P15F35S type connectors. The connector characteristics and contact assignments are listed in Tables XXXI and XXXII.

a. The Investigation provided connector shall be of type MS27467T15F35P and shall be compatible with the contact assignments defined in Tables XXXI and XXXII.

b. Contacts 25 and 26 shall be bridged inside the experiment system to assure proper operation of the inhibit. It is required to place the inhibit link in the connector.

c. The Investigation provided spotlight/equipment shall have a maximum power rating of +12V/2A (24W).

d. The max inrush current shall not be greater than 2 x nominal operating current for up to 10 ms.

e. For thermal reasons the spotlight shall not be covered while on.

f. The Investigation provided spotlight/equipment shall meet the bonding requirements of section 3.2.4.2 or use pin 24 to ensure a proper bonding path.

Table XXXI . WV ICP Connector Contact Assignments

Connector Label: J304, ICP		Connector Type: MS27656P15F35S
Contact	**Internal Wire AWG**	**Function/Description**
1	22D	N/A for Investigations
2	22D	N/A for Investigations
3	22D	N/A for Investigations
4	22D	N/A for Investigations
5	22D	N/A for Investigations
6	22D	N/A for Investigations
7	22D	N/A for Investigations
8	22D	N/A for Investigations
9	22D	N/A for Investigations
10	22D	N/A for Investigations
11	22D	N/A for Investigations
12	22D	N/A for Investigations
13	22D	N/A for Investigations
14	22D	N/A for Investigations
15	22D	N/A for Investigations
16	22D	N/A for Investigations
17	22D	N/A for Investigations
18	22D	N/A for Investigations
19	22D	N/A for Investigations
20	22D	N/A for Investigations
21	22D	N/A for Investigations
22	22D	N/A for Investigations
23	22D	N/A for Investigations
24	22D	Chassis
25	22D	RTN Inhibit 1
26	22D	Inhibit 1 (+12V Power)
27	22D	RTN for +12V/2A Power
28	22D	+12V/2A Power
29	22D	N/A for Investigations
30	22D	N/A for Investigations
31	22D	N/A for Investigations
32	22D	N/A for Investigations
33	22D	N/A for Investigations
34	22D	N/A for Investigations
35	22D	N/A for Investigations
36	22D	N/A for Investigations
37	22D	N/A for Investigations

Table XXXII. ICP OUTLET Connector Contact Assignments

Connector Label: J334, Spotlight Interface	Connector Type: MS27656P15F35S	
Contact	**Internal Wire AWG**	**Function/Description**
1	22D	N/A for Investigations
2	22D	N/A for Investigations
3	22D	N/A for Investigations
4	22D	N/A for Investigations
5	22D	N/A for Investigations
6	22D	N/A for Investigations
7	22D	N/A for Investigations
8	22D	N/A for Investigations
9	22D	N/A for Investigations
10	22D	N/A for Investigations
11	22D	N/A for Investigations
12	22D	N/A for Investigations
13	22D	N/A for Investigations
14	22D	N/A for Investigations
15	22D	N/A for Investigations
16	22D	N/A for Investigations
17	22D	N/A for Investigations
18	22D	N/A for Investigations
19	22D	N/A for Investigations
20	22D	N/A for Investigations
21	22D	N/A for Investigations
22	22D	N/A for Investigations
23	22D	N/A for Investigations
24	22D	Chassis
25	22D	RTN Inhibit 1
26	22D	Inhibit 1 (+12 V/2A Power)
27	22D	RTN for +12V/2A Power
28	22D	+12V/2A Power
29	22D	N/A for Investigations
30	22D	N/A for Investigations
31	22D	N/A for Investigations
32	22D	N/A for Investigations
33	22D	N/A for Investigations
34	22D	N/A for Investigations
35	22D	N/A for Investigations
36	22D	N/A for Investigations
37	22D	N/A for Investigations

3.7.3 WV Environment

The WV is capable of providing a Class 100K environment as defined in FED-STD-209. The WV provides a removal efficiency of 99.97% for particulate matter of 0.3 microns are larger in aerodynamic diameter.

a. Investigations shall be safe when exposed to a WV negative pressure of ≥ 1.3 mbar relative to cabin pressure.

b. Investigation shall not cause an overpressurization of the WV, that being 20 mbar negative delta p and 15 mbar positive delta p.

c. Investigations that provide only one layer of containment for liquids in the WV shall limit the amount of liquid it contains to no more than 50 cc or the quantity stated in Table XXXIII, whichever is less, when using a fan speed setting of 4. These materials are compatible with the MSG WV, but Station may limit the use of them. Materials that could be released in the WV and any byproducts given off (etc. from combustion experiments) by the Investigation not listed in Table XXXIII, volumes larger than what is specified in Table XXXIII or require a fan speed setting greater that 4 shall be approved by the IIT. Materials that could be released in the WV shall be compatible with MSG hardware as defined section 3.9.1.2.b.

d. Investigations shall be compatible with the following WV dimensions listed below. Investigations, when mounted in the WV:

   - Shall leave adequate space from the front window, sideports and gloveports for crew interaction, see Figure 5.
   - Shall leave adequate space from the connectors and QDs shown in Figures 2 and 5.
   - Shall maintain a two inch (50.8mm) clearance form the filter banks so adequate air flow is maintained, cables excluded.

   Investigations that approach or exceed the exclusion zone described above shall be tested, per section 3.1.1.3 at the L-22 Investigation physical interface test, in the facility to insure there is no interference with MSG hardware during Investigation operations.

   The approximate Dimensions of the WV are:
   - Internal volume: 255 liters
   - Width: 906 mm
   - Depth bottom: 500 mm
   - Depth top: 385 mm
   - Height: 638 mm

e. Investigations or equipment articles which must be transferred to the WV through the 406 mm side port shall be compatible with the following dimensions:

- diameter: $\leq$ 406 mm
- area: 25 cm x 30 cm

f. Investigations requiring transfer to the WV through the airlock shall be limited in volume to the following dimensions:

  - 25.4 cm x 34.3 cm x 29.9 cm (26 liters)
  - Investigation will work with the IIT for transfer requirements/procedures and tray location/dimensions when using the airlock.

Table XXXIII. WV Fluid Containment Quantities

Material	Amount Handled
Water (liquid or vapor)	50 cc
Cleaning solvents as required for LSE, cleaning equipment.	50 cc
Ethanol (liquid or vapor)	50 cc
Methanol	20 cc
Butanol (liquid or vapor)	50 cc
Decane (liquid or vapor)	50 cc
Heptane (liquid or vapor)	50 cc
Silicon Oils	20 cc
Non-volatile combustible solid fuels: Paper, Polyethylene, PMMA (Plexiglass)	50 cc
Glycerin (liquid or vapor)	50 cc
Chlorofluorocarbon (Refrigerants)	50 cc
Electrolytic Fluids such as coppersulfate/acid solutions.	50 cc
Polyethylene Glycol	50 cc
Aqueous solutions with pH ranging from 3 to 9.	50 cc

Note: Approval of the use of alcohol shall be worked through the IIT see section 3.7.4.3. These quantities are based on a fan speed setting of 4. The amount of fluid one filter can contain is dependent on the airflow through the filter, testing with water showed containment of 50cc at fan speed setting of 4. Depending on thermal requirements the investigation may require a higher fan speed, which they will work through the IIT.

3.7.4 Investigation Use of Cabin Atmosphere

3.7.4.1 Active Air Exchange

Active air exchange with the cabin atmosphere by Investigation shall be limited to air exchange for specimen metabolic purposes and for mass conservation purposes.

3.7.4.2 Oxygen Consumption

Investigations consumption of atmospheric oxygen shall not exceed 1.08 kg per day (2.38 lbs/day).

3.7.4.3 Chemical Releases

Investigations that use chemicals that would create a toxicity problem or cause a hazard to ISS or MSG hardware if released shall provide adequate containment. Containment shall be provided by the use of a pressure vessel or the use of two or three redundantly sealed containers, depending on the toxicological hazard for a chemical with a vapor pressure below 15 psia. The Investigation must assure that each level of containment will not leak under the maximum use conditions (i.e. vibration, temperature, pressure, etc.)

The release of methanol, ethanol, isopropyl alcohol, n-propyl alcohol, n-butyl alcohol, acetone, ethylene glycol, and propylene glycol into the ISS habitable environment shall be prohibited. The release of these compounds due to normal materials offgassing is exempt from this requirement.

3.7.4.4 Cabin Air Heat Leak

The sensible heat leak to the cabin air from the investigation hardware operating outside the WV shall be no greater than the maximum values identified in the Unique Investigation ICD. These limits represent the total cabin air heat load capability when the cabin temperature is at 18°C (65°F).

3.7.5 Ionizing Radiation Requirements

3.7.5.1 Investigation Contained or Generated Ionizing Radiation

Investigations containing or using radioactive materials or that generate ionizing radiation shall be identified and approval obtained for their use.

3.7.5.2 Ionizing Radiation Dose

Investigations should expect a total dose of ionizing radiation of 30 Rads(Si) per year.

3.7.5.3 Single Event Effect (SEE) Ionizing Radiation

Investigations will be designed to not produce an unsafe condition or one that could cause damage to the MSG as a result of exposure to SEE ionizing radiation. Exposure levels are specified in SSP 30512, paragraph 3.2.1, assuming exposure levels with a shield thickness of 25.4mm (1000 mils).

3.8 Fire Protection Interface Requirements

Investigations must not constitute an uncontrolled fire hazard to the ISS or other payloads. The minimum use of flammable materials shall be the preferred means of hazard reduction.

3.8.1 MSG WV Monitoring and Detection

The probability of fire and the detection thereof, for Investigations within the WV are dependent on many factors. These factors have been studied with the following results:

a. Smoke sensors in the Air Handling Unit (AHU) ducts are not used to detect fire inside the WV.

b. The MSG provides special power down features for the power interfaces contained within the work volume. If an over-temperature is detected in the WV, power will be removed from the WV EXP OUTLETS 1,2,3 and the ICP power outlets.

c. The one WV air temperature analog sensor and four bilevel air temperature sensors located on the WV rear wall will be implemented to detect over-temperature possibly created by fire. The sensors trigger a message to the ISS Data Handling System (DHS) via the MIL-STD-1553B bus.

d. The MSG will provide operational modes without airflow in the WV; however, dependence on the air temperature sensors for fire detection requires airflow.

3.8.1.1 Investigation Monitoring and Detection

a. Fire detection shall be required where an investigation provides potential ignition sources and/or flammable materials. Some Investigations may, with hazard analysis and approval of the PSRP, rely on the fire detection capability of the MSG, as provided in section 3.8.1.c.

b. Investigations that require the use of flammable materials shall limit the quantity to minimize the risk.

c. Parameter monitoring may be implemented by the Investigation to meet the fire detection requirement, if the MSG does not provide adequate coverage. This monitoring shall provide warning to the ISS, via the SPLC, prior to the initiation of a combustion event in order to allow timely action by the crew and/or ground control. This parameter monitoring may be used in conjunction with the MSG fire detection capability as stated in section 3.8.1.c. The Investigation shall comply with section 3.3.1.2.2.2.2 when implementing fire detection/annunciation requirements.

d. Investigations that can not prove, by analysis, that loss of cooling does not produce a credible fire hazard, shall provide temperature sensors and parameters monitoring that will remove power from the payload in the case that the temperature goes above safe limits, as described in section 3.8.1.1.c.

e. Combustion investigations shall be performed under crew surveillance.

3.8.1.2 Investigation Fire Suppression

The WV provides a fire suppression port for use of the ISS PFE. The fire suppression port is covered with a fire port sticker. Figure 31 shows the location of the WV fire suppression port.

a. Investigation shall provide a means for fire containment for any equipment that poses a credible risk of fire outside the envelope identified in paragraph 3.8.1.

b. Investigation hardware located outside the WV shall work with the IIT and PSRP on a case-by-case basis for fire detection and suppression requirements.

c. Investigations shall use materials and parts that meet the material requirements specified in paragraph 3.9 of this IRD.

3.9 Materials and Parts Interface Requirements

3.9.1 Materials and Parts Use And Selection

Investigations shall use materials and parts that meet the materials requirements specified in NSTS 1700.7, ISS Addendum. This requirement also applies to all Commercial/Off the shelf (COTS) parts used in the investigation.

For those NASA centers which participate in the NASA Materials and Processes Intercenter Agreement for ISS payloads, the Intercenter Agreement baselines the process for selection and certification of materials used in payload hardware to the safety requirements of NSTS 1700.7 and NSTS 1700.7 ISS Addendum, paragraphs 208.3 and 209 in their entirety.

Whenever possible, materials should be selected that have already been shown to meet the applicable acceptance test criteria. Existing test data are compiled in the NASA Marshall Space Flight Center (MSFC) Materials and Process Technical Information System (MAPTIS) electronic database. A hardcopy version of the MAPTIS database is published periodically as a joint document with Johnson Space Center (JSC), MSFC-HDBK-527/JSC 09694, Materials Selection List for Space Hardware Systems.

3.9.1.1 Commercial Parts

Deleted

3.9.1.2 Additional Investigation Material Requirements

a. All Investigator hardware shall meet the toxicity offgassing acceptance requirements of NASA-STD-6001, Test 7.

b. Investigations shall verify that any materials they could release into the WV, including sample material and byproducts of the investigation, are compatible with the MSG WV surfaces, Air Lock surfaces, filters, gloves and any other supplied hardware. The list of the WV materials to be analyzed is provided in Appendix F of this document.

c. Investigations shall maintain two or more levels of containment, depending on the toxicological hazard determined by the PSRP, during operations in the MSG if its materials or byproducts meet any of the following conditions. 1) they constitute a catastrophic toxic hazard according to the PSRP; 2) they are incompatible with the MSG hardware or other hardware that will occupy the MSG during the investigation's operations; 3) their volumes would saturate the MSG air filters or otherwise exceed the ability of the MSG to contain these materials if they were released into the WV.

d. Investigations using materials that are not listed in Table XXXIII shall provide their own cleaning tools/wipes etc., in case of spillage and take care of waste disposal. Investigation tools used for cleaning shall be approved by the IIT to insure the MSG WV will not be damaged. The investigation shall include in their crew procedures the wipe down of the accessible surfaces in the WV if released materials or byproducts will leave any residue on the WV surfaces and the equipment it contains to remove any resulting contamination.

e. Investigations that are to remain on-orbit for more than one year shall use fungus resistant materials.

f. Investigations will develop crew procedure steps for cleaning up liquid spillage or other release of materials within the WV, as defined section 3.10.8.5.h., j. and k.

g. The Investigation shall provide disclosure of the contents (including flammability, pH, toxicity) of all substances/samples including proprietary material used in or produced by the investigation to the JSC Toxicology Group in accordance with NSTS/ISS 13830 and JSC 27472. The Investigation shall comply with the toxic labeling standards in NSTS 07700, Volume XIV.

3.9.2 Cleanliness

Investigations shall conform to Visibly Clean-Sensitive (VC-S) cleanliness requirements. Visibly clean is defined as the absence of all particulate and nonparticulate matter visible to the normal unaided eye.

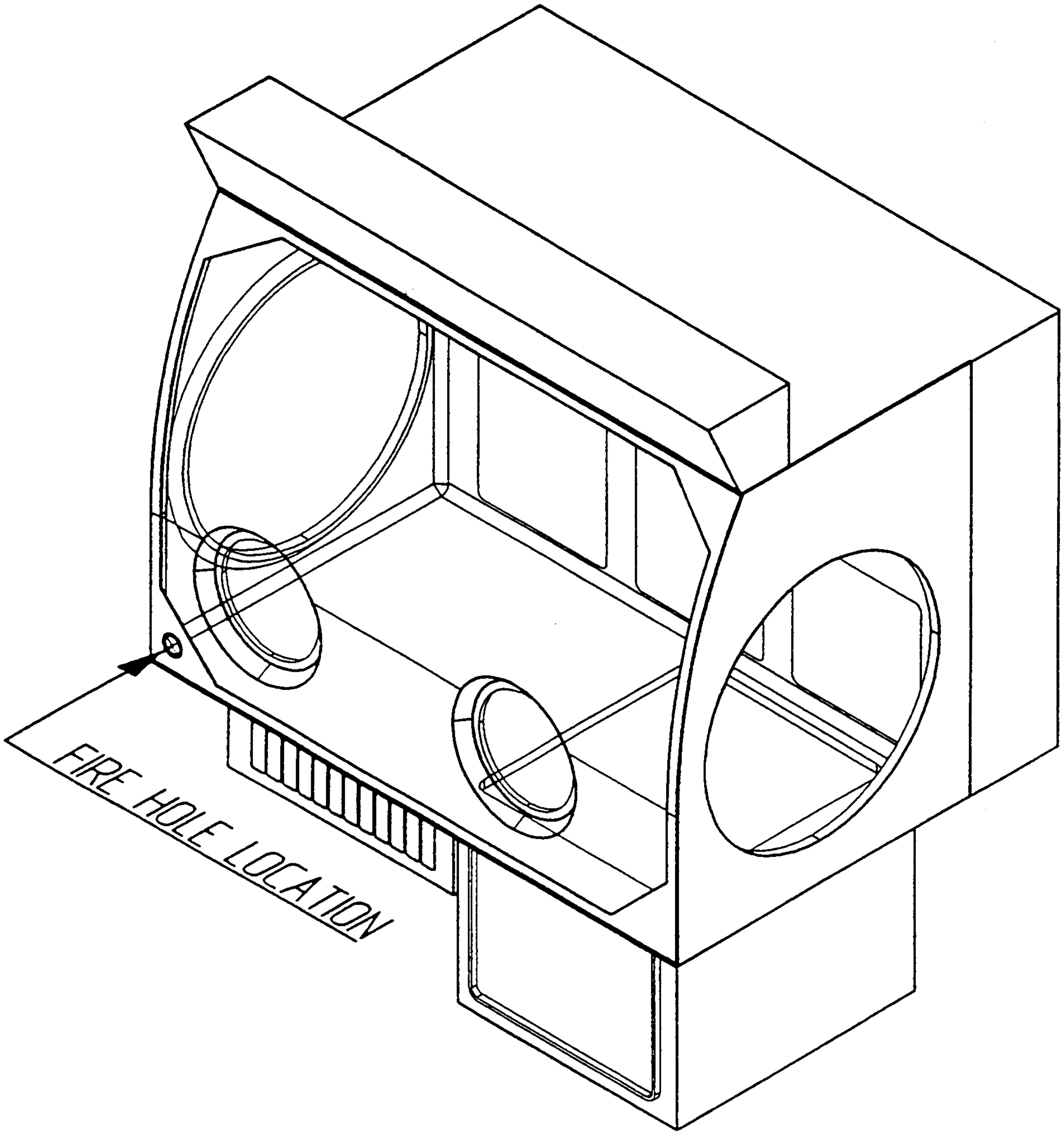


Figure 31. WV Fire Suppression Port

3.10 Human Factors Interface Requirements

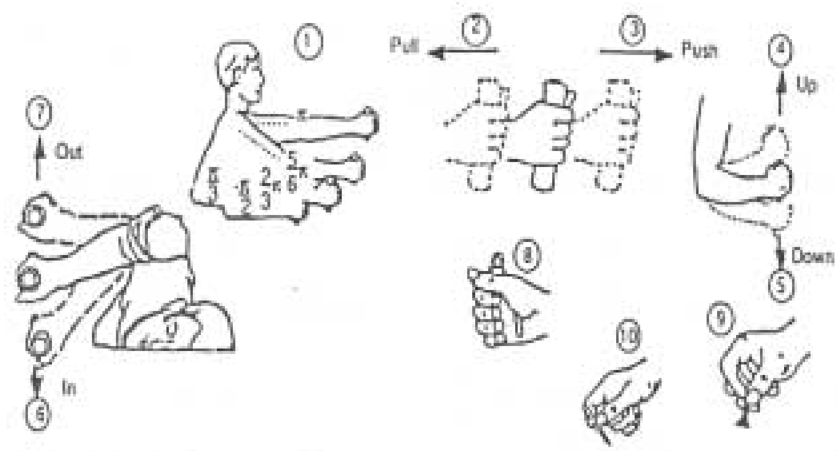
3.10.1 Strength Requirements

Forces and torque's required to remove, replace, operate, control, and maintain payload hardware and equipment on-orbit shall be equal to or less than the strength values given below. For operation and control of payload hardware equipment:

a. Grip Strength – To remove, replace and operate payload hardware, grip strength required shall be less than 254 N (57lbf).

b. Linear Forces – Linear forces required to operate or control hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 50% of the strength values shown in Figure 32.

c. Torques – Torques required to operate or control payload hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability shown in Figure 33.



Arm strength (N)														
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (rad)	Pull		Push		Up		Down		In		Out	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	89	36	62
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand and thumb-finger strength (N)				
	(8)		(9)	(10)
	Hand grip			
	L	R	Thumb-finger grip (Palmar)	Thumb-finger grip (tips)
Momentary hold	250	260	60	60
Sustained hold	145	155	35	35

* Elbow angle shown in radians
** L = Left, R = Right

Arm strength (lb)														
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (deg)	Pull		Push		Up		Down		In		Out	
	L	R*	L	R	L	R	L	R	L	R	L	R
180	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	15
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	18	20	17	20	12	17

Hand, and thumb-finger strength (lb)				
	(8)		(9)	(10)
	Hand grip			
	L	R	Thumb-finger grip (Palmar)	Thumb-finger grip (tips)
Momentary hold	56	59	13	13
Sustained hold	33	35	8	8

* Left, R = Right

Figure 32. <u>Arm, Hand and Thumb/Figure Strength</u>
(5th Percentile Male Data)

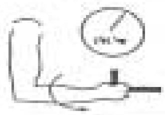
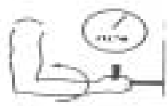
	Unpressurized suit, bare handed	
	Mean	SD
 Maximum torque: Suppination, Nm (lb-in.)	13.73 (121.5)	3.41 (30.1)
 Maximum torque: Pronation, Nm (lb-in.)	17.39 (153.9)	5.08 (45.0)

Figure 33. <u>Torque Strength</u>

3.10.2 Habitability

3.10.2.1 Housekeeping

3.10.2.1.1 Closures Or Covers

Investigations closure/cover shall be provided for any area of the payload that is not designed for routine cleaning.

3.10.2.1.2 Built -In Control

a. Investigation containers of liquids or particulate matter shall have built-in equipment/methods for control of vaporization, material overflow, or spills.

b. Investigation capture elements, including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials.

3.10.2.1.3 One-Handed Operation

Investigation cleaning equipment and supplies shall be designed for one-handed operation or use.

3.10.2.2 Touch Temperature

3.10.2.2.1 Continuous/Incidental Contact-High Temperature

Investigations surfaces whose temperature exceeds 49° C (120° F), which are subject to continuous or incidental contact, are exposed to crewmember's bare skin contact, protective equipment shall be provided to the crew and warning labels shall be provided at the surface site, see NSTS 18798 Interpretation letter MA2-95-048.

3.10.2.2.2 Continuous/Incidental Contact-Low Temperature

Investigations surfaces below –18° C (0° F), which are subject to continuous or incidental contact, are exposed to crewmember's bare skin contact, protective equipment shall be provided to the crew and warning labels shall be provided at the surface site, see NSTS 18798 Interpretation letter MA2-95-048.

3.10.2.2.3 Acoustic Requirements

a. Investigations shall comply with the acoustic requirements in Table XXXIV. The investigation shall perform an acoustics test on the hardware to verify the requirements are met. The sound pressure limits given in Table XXXIV have the noise attenuation that the WV provides incorporated into them. Investigations not complying with the acoustic requirements shall require a waiver.

b. Investigations shall not exceed the A-weighted sound pressure level SPL limits during the Maximum Noise Duration as specified in Table XXXV when the equipment is operating in the loudest expected configuration and mode of operation that can occur on orbit under planned operations. The Maximum Noise Duration is the total time that the investigation produces noise above the Continuous Noise Limits during a 24 hour time period. This duration is the governing factor in determining the allowable Intermittent Noise Limits. Regardless of the number of separate sources and varying durations, this cumulative duration shall be used to determine the A-weighted SPL limit in Table XXXV. The investigation shall perform an acoustics test on the hardware to verify the requirements are met. The A-weighted SPL limits given in Table XXXV have the noise attenuation that the WV provides incorporated into them. Investigations not complying with the Maximum Noise Duration shall require a waiver.

Note: To be compliant with the integrated rack continuous noise acoustic requirement only AHU fan modes of 4 and 7 are approved for continuous operation.

Table XXXIV . Investigation Continuous Noise Requirements

Noise Limits measured at 0.6 meters distance from test article	
Frequency Band (Hz)	**Investigation** Sound Pressure **Limit (dB)**
63	70
125	63
250	60
500	49
1,000	48
2,000	52
4,000	49
8,000	52

Note: The Investigation SPL is to be measured at a distance of 0.6 meters from the test article or 0.6 meters from the integrated rack.

Table XXXV. Investigation Intermittent Noise Limits

Noise Limits Measured at 0.6 meters distance from test article	
Maximum Noise Duration	**Investigation** A-weighted **SPL Limit (dBA)**
8 Hours	57
7 Hours	58
6 Hours	59
5 Hours	60
4.5 Hours	61
4 Hours	62
3.5 Hours	63
3 Hours	65
2.5 Hours	66
2 Hours	68
1.5 Hours	70
1 Hours	73
30 Minutes	77
15 Minutes	79
5 Minutes	81
2 Minutes	82
1 Minutes	84
Not Allowed	85

3.10.2.2.4 Lighting Design

Investigation lighting sources shall be dimmable.

3.10.3 Structural/Mechanical Interfaces

3.10.3.1 Equipment Mounting

Investigations items used during nominal operations and planned maintenance shall be designed, labeled, or marked to protect against improper installation.

3.10.3.2 Unique Tools

Investigation provided unique tools shall meet the applicable requirements defined as applicable in the MSG IIRD. Power tools shall be designed so the battery packs can be replaced and have a level-of-charge indicator or an indicator as to when the battery pack is required to be replaced or recharged.

3.10.3.3 Connectors

Investigation connectors shall meet the following requirements.

3.10.3.3.1 One-Handed Operation

All Investigation ORU connectors, whether operated by hand or tool, shall be designed and placed so they can be mated/demated using either hand.

3.10.3.3.2 Accessibility

Investigation connectors shall be designed so it is possible to mate/demate individual connectors without having to remove or mate/demate other connectors. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors.

3.10.3.3.3 Ease of Disconnect

Electrical connectors shall require no more than two turns to disconnect.

3.10.3.3.4 Self Locking

Payload electrical connectors shall provide a self-locking feature.

3.10.3.3.5 Connector Arrangement

Space between connectors and adjacent obstructions shall be a minimum of 25mm (1 inch) for access. Connectors in a single row or staggered rows which are removed sequentially by the crew shall provide 25mm (1inch) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence.

3.10.3.3.6 Arc Containment

Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks.

3.10.3.3.7 Connector Protection

Protection shall be provided for all demated connectors against physical damage and contamination.

3.10.3.3.8 Connector Shape

Investigations connectors shall use different connector shapes, sizes or keying to prevent mating connectors when lines differ in content.

3.10.3.3.9 Fluid and Gas Line connectors

Investigations fluid and gas connectors that are mated and demated shall be located and configured so that they can be visually inspected for leakage.

3.10.3.3.10 Coding

Both halves of mating connectors shall display a code or identifier that is unique to that connection. The labels or codes on connectors shall be located so they are visible when connected or disconnected.

3.10.3.3.11 Pin Identification

Each pin shall be uniquely identifiable in each electrical plug and each electrical receptacle, except for MSG facility and investigations, which shall have the option of either labeling every 10th pin or providing procedures/specifications that allow the pins to be identified. Crew procedures shall be provided through the OCR process for any flight maintenance required on-orbit to repair a connector.

3.10.3.3.12 Orientation

Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position.

3.10.3.3.13 Alignment Marks or Guide Pins

Mating parts shall have alignment marks in a visible location during mating or guide pins (or their equivalent).

3.10.3.4 Fasteners

Investigation provided fasteners that are removed on-orbit shall meet the following requirements.

3.10.3.4.1 Non-Threaded Fasteners Status Indication

An indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided.

3.10.3.4.2 Mounting Bolt/Fastener Spacing

Clearance around fasteners to permit fastener hand threading (if necessary) shall be a minimum of 0.5 inches for the entire circumference of the bolt head and a minimum of 1.5 inches over 180 degrees of the bolt head and provide the tool handle sweep as seen in Figure 34.

3.10.3.4.3 Multiple Fasteners

When several fasteners are used on one item they shall be of identical type.

3.10.3.4.4 Captive Fasteners

All fasteners planned to be installed and/or removed on-orbit shall be captive when disengaged.

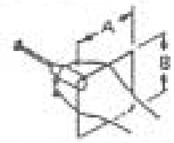
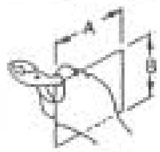
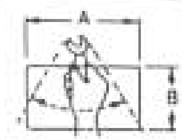
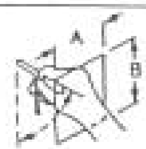
Opening dimensions		Task
	A 117 mm (4.6 in) B 107 mm (4.2 in)	Using common screw-driver with freedom to turn hand through 180°
	A 133 mm (5.2 in) B 115 mm (4.5 in)	Using pliers and similar tools
	A 155 mm (6.1 in) B 135 mm (5.3 in)	Using T-handle wrench with freedom to turn wrench through 180°
	A 203 mm (8.0 in) B 135 mm (5.3 in)	Using open-end wrench with freedom to turn wrench through 62°
	A 122 mm (4.8 in) B 155 mm (6.1 in)	Using Allen-type wrench with freedom to turn wrench through 62°

Figure 34. <u>Minimal Clearance for Tool-Operated Fasteners</u>

3.10.3.4.5 Quick Release Fasteners

Quick release fasteners shall require a maximum of one complete turn to operate (quarter –turn fasteners are preferred). Quick release fasteners shall be positive locking in open and closed positions.

3.10.3.4.6 Threaded Fasteners

Only right handed threads shall be used.

3.10.3.4.7 Over Center Latches

Nonself-latching – Over center latches shall include a provision to prevent undesired latch element realignment, interface, or reengagement.

Latch lock – Latch catches shall have locking features.

Latch handles – If the latch has a handle, the latch handle and latch release shall be operable by one hand.

3.10.3.4.8 Winghead Fasteners

Winghead fasteners shall fold down and be retained flush with surfaces.

3.10.3.4.9 Fastener Head Type

Hex type external or internal grip or combination head fasteners shall be used where on-orbit crew actuation is planned. If a smooth surface is required, flush or oval head internal hex grip fasteners shall be used for fastening. Slotted fasteners shall not be used to carry launch loads for hard-mounted equipment. Slotted fasteners are allowed in non-structural applications (e.g., computer data connectors, stowed commercial equipment).

3.10.3.4.10 One-Handed Actuation

Fasteners planned to be removed or installed on-orbit shall be designed and placed so they can be mated/demated using either hand.

3.10.3.4.11 Deleted

3.10.3.4.12 Access Holes

Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and hand or necessary tool if either is required to replace).

3.10.4 Controls and Displays

Investigation controls and displays shall meet the following requirements.

3.10.4.1 Controls Spacing Design Requirements

All spacing between controls and adjacent obstructions shall meet the minimum requirements for ungloved operations as shown in Figure 35. When operations require gloved hands the preferred requirements will be met.

3.10.4.2 Protective Methods

Payloads shall provide protection against accidental control actuation using one or more of the protective methods listed in sub–paragraphs a. through c. below. Infrequently used controls (i.e. those used for calibration) should be separated from frequently used controls. Leverlock switches or switch covers are strongly recommended for switches related to mission success. Switch guards may not be sufficient to prevent accidental actuation.

a. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier.

b. Cover or guard the controls. Safety or lock wire shall not be used.

c. Cover guards when open shall not cover or obscure the protected control or adjacent controls.

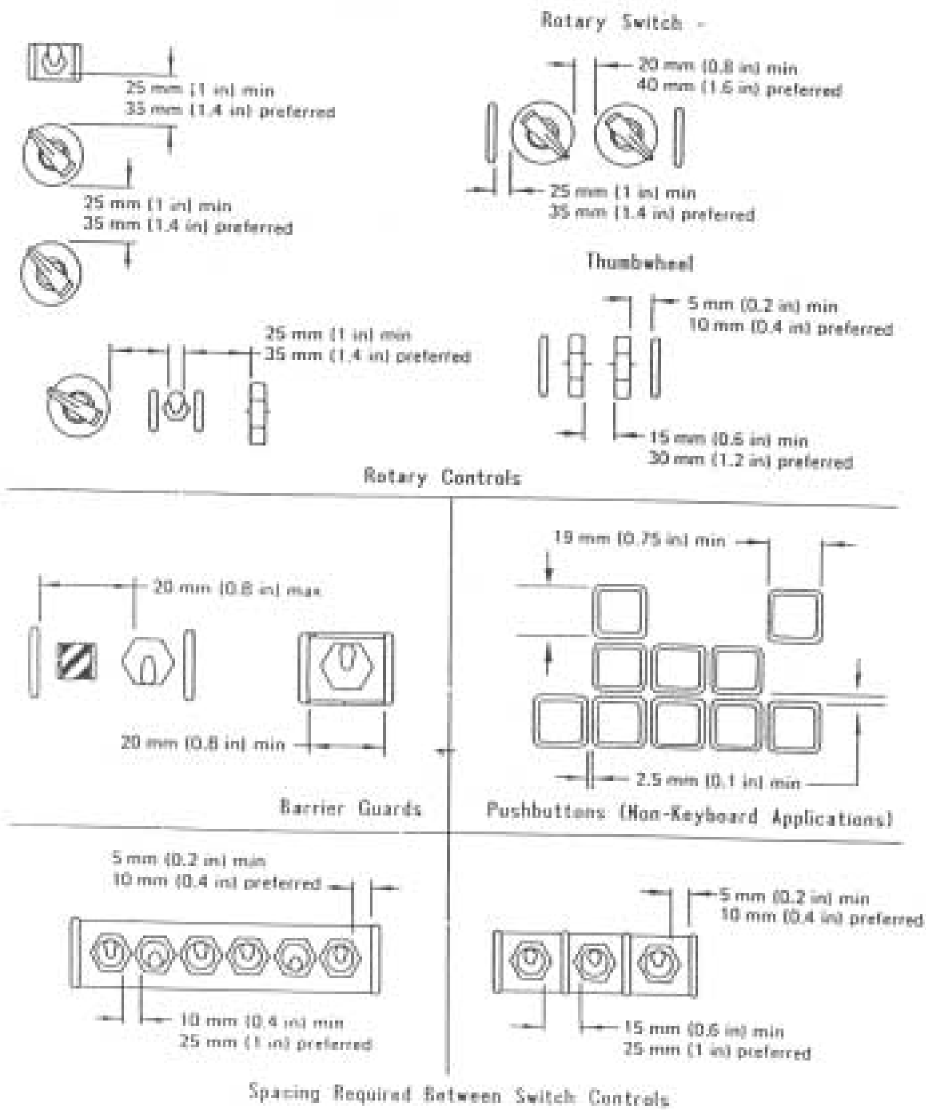


Figure 35. Control Spacing Requirements

3.10.4.3 Noninterference

Investigation provided protective devices shall not cover or obscure other displays or controls.

3.10.4.4 Barrier Guards

Barrier guard spacing shall adhere to the requirements for use with the toggle switches, rotary switches, and thumbwheels as shown in Figures 35 and 36.

3.10.4.5 Recessed Switch Protection

When a barrier guard is not used, rotary switches that control critical functions shall be recessed as shown in Figure 36.

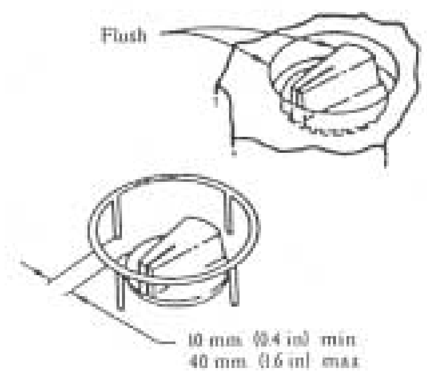


Figure 36. Rotary Switch Guard

3.10.4.6 Position Indication

When payload switch protective covers are used, control position shall be evident without requiring cover removal.

3.10.4.7 Hidden Controls

Controls that cannot be directly viewed will be avoided. If present, hidden controls shall be guarded to protect against inadvertent actuation.

3.10.4.8 Hand Controllers

Hand controllers, excluding trackballs and mouse, shall have a separate on/off control to prevent inadvertent actuation when the controller is not in use.

3.10.4.9 Valve Controls

Requirements for design of investigation valve controls are defined as follows:

a. Low-Torque Valves – Valves requiring 1 N–m (10 in–lb) or less for operation are classified as “low-torque” valves and shall be provided with a “central pivot” type handle, 5.5 cm (2.25 in) or less in diameter. (see Figure 37)

b. Intermediate-Torque Valves – Valves requiring between 1 and 2 N–m (10 and 20 in–lb) for operation are classified as “intermediate torque” valves and shall be provided with a “central pivot” type handle, 5.5 cm (2.25 in) or greater in diameter, or a “lever (end pivot type” handle, 7.5 cm (3 in) or greater in length.

c. High-Torque Valves – Valves requiring 2 N–m (20 in–lb) or more for operation are classified as “high-torque” valves and shall be provided “lever type” handles greater than 7.5 cm (3 in) or greater in length.

d. Handle Dimensions – Valve handles shall adhere to the clearances and dimensions illustrated in Figure 37, Valve Handle-Central Pivot Type and Figure 38, Valve Handle-Lever Type.

e. Rotary Valve Controls – Rotary valve controls shall open the valve with a counter-clockwise motion.

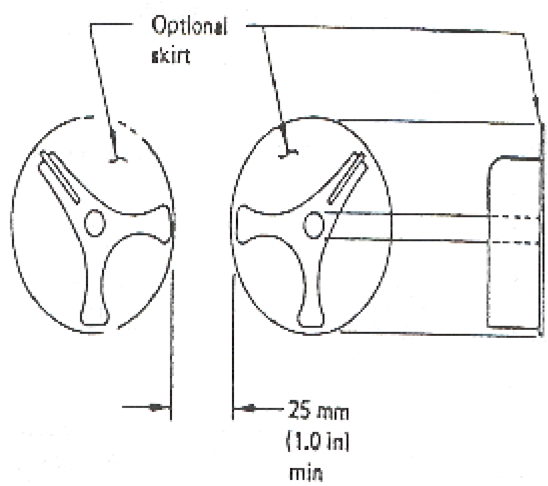


Figure 37. **Valve Handle – Central Pivot Type**

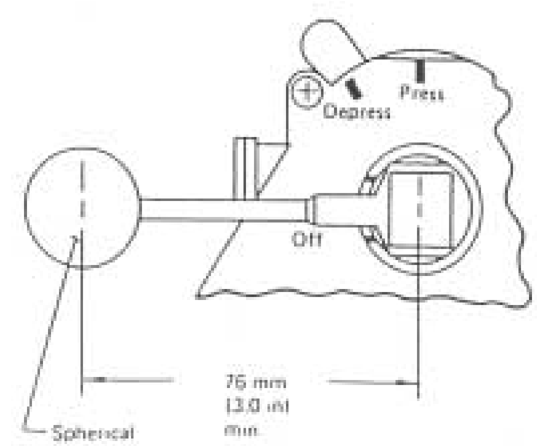
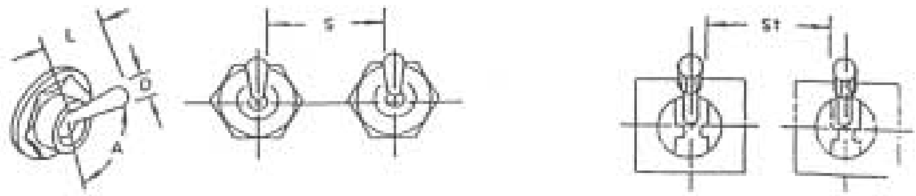


Figure 38. Valve Handle – Lever Type

3.10.4.10 Toggle Switches

Dimensions for a standard toggle switch shall conform to the values presented in Figure 39.



	Dimensions		Resistance	
	L Arm length	D Control tip	Small switch	Large switch
Minimum	13 mm (1/2 in)	3 mm (1/8 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	50 mm (2 in)	25 mm (1 in)	4.5 N (16 oz)	11 N (40 oz)

	Displacement between positions A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Desired		25°

	Separation S			
	Single finger operation		Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (3/4 in)	25 mm (1 in)	13 mm (1/2 in)	16 mm (5/8 in)
Optimum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	19 mm (3/4 in)

Figure 39. Toggle Switches

3.10.5 Deleted

3.10.5.1 Stowage Container Contents Restraints

a. Investigation container (i.e. small parts box, sample holder) contents shall be restrained in such a way that the items do not float when the container is opened or closed.

b. Investigation container contents shall be restrained in a way such that the items do not jam the drawer when the container is opened or closed.

c. Investigation container contents shall be restrained in such a way that the contents can be removed/replaced without using a tool.

3.10.5.2 Stowage and Equipment Containers

a. Investigation container (i.e. small parts box, sample holder) latches, handles, and operating mechanisms shall be designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male to the 5th percentile female.

b. The design of latches shall be such that their status (locked/unlocked) can be determined through visual inspection.

3.10.5.3 Captive Parts

Investigation equipment shall be designed in such a manner to ensure that all unrestrained parts (e.g., locking pins, knobs, handles, lens covers, access plates, or similar devices) that may be temporarily removed on orbit will be tethered or otherwise held captive. The MSG provides Velrco Strips that may be attached within the WV for restraining investigation equipment.

3.10.5.4 Handles and Restraints

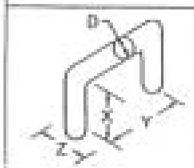
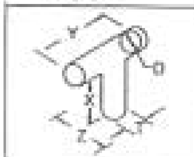
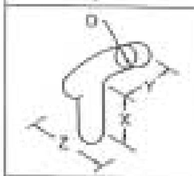
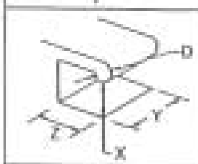
Investigation hardware items that are larger than 1ft^3 shall be provided with handles or other suitable means of grasping, tethering, carrying, and restraining.

3.10.5.5 Handle Location/Front Access

Handles and grasp areas shall be placed on the accessible surface of a payload item consistent with the removal direction.

3.10.6 Handle Dimensions

Handles for movable or portable units shall be designed in accordance with the minimum applicable dimensions in Figure 40.

Illustration	Type of handle	Dimensions in mm (in inches) (Bare hand)		
		X	Y	Z
	Two-finger bar One-hand bar Two-hand bar	32 (1−1/4) 48 (1−7/8) 48 (1−7/8)	65 (2−1/2) 111 (4−3/8) 215 (8−1/2)	75 (3) 75 (3) 75 (3)
	T-bar	38 (1−1/2)	100 (4)	75 (3)
	J-bar	50 (2)	100 (4)	75 (3)
	Two-finger recess One-hand recess	32 (1−1/4) 50 (2)	65 (2−1/2) 110 (4−1/4)	75 (3) 90 (3−1/2)
	Finger-tip recess One-finger recess	19 (3/4) 32 (1−1/4)	— —	13 (1/2) 50 (2)
Curvature of handle or edge (DOES NOT PRECLUDE USE OF OVAL HANDLES)	Weight of Item Up to 6.8 kg (up to 15 lbs) 6.8 to 9.0 kg (15 to 20 lbs) 9.0 to 18 kg (20 to 40 lbs) Over 18 kg (over 40 lbs) T-bar post	Minimum diameter D = 6 mm (1/4 in) D = 13 mm (1/2 in) D = 19 mm (3/4 in) D = 25 mm (1 in) T = 13 mm (1/2 in)	Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π rad (120°) or more	

Note: x = height, y = handle width, z = folding/flop length of the handle

Figure 40. Minimum Handle Dimensions

3.10.7 Identification Labeling

The development of labels shall be a joint process requiring the cooperative efforts of ISS Payload Label Approval Team (IPLAT) at JSC, MSG Investigation Integration Team and the MSG Investigator.

The Investigator shall provide label drawings, label location drawings and information sufficient to enable IPLAT to determine that the labeling instructions are met. The labeling instructions are found in Appendix C of this document. The Investigator shall coordinate with the MSG Integration Team before submitting the label drawings for approval. IPLAT is responsible for reviewing all payload labels, providing guidance to the MSG Team/Investigator and granting approval. IPLAT is also responsible for performing a human engineering assessment of the labels and ensuring the labels are appropriate from a human engineering perspective including commonality, standardization, and operations nomenclature.

Decals needed by the Investigators that are available in JSC 27260, Decal Process Document and Catalog must be obtained from the Decal Design & Production Facility (DDPF). Examples of labels found in the catalog are: IMS, PFE, toxicology, hazardous, cautions and warning, rack power switch, fire indicators, etc. The DDPF is also available to the Investigators for fabricating labels not found in JSC 27260.

3.10.8 Crew Safety

3.10.8.1 Electrical Hazards

Deleted

3.10.8.2 Mismatched

The design of electrical connectors shall make it impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created. Payload and on-orbit support equipment, wire harnesses, and connectors shall be designed such that no blind connections or disconnections must be made during payload installation, operation, removal, or maintenance on orbit or during ground operations at KSC unless the design includes scoop proof connectors or other protective features.

For payload equipment, for which mismating or cross-connection may damage ISS or MSG provided equipment, plugs, and receptacles (connectors), shall be selected and applied such that they cannot be mismatched or cross-connected in the intended system as well as adjacent systems. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mismating.

For all other payload connections, combinations of identification, keying and clocking, and equipment test and checkout procedures shall be employed at the payload's discretion to minimize equipment risk while maximizing on-orbit operability.

3.10.8.3 Overload Protection

3.10.8.3.1 Device Accessibility

An overload protective device shall not be accessible without opening a door or cover, except that an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure.

3.10.8.3.2 Extractor –Type Fuse Holder

The design of the extractor-type fuse holder shall be such that the fuse is extracted when the cap is removed.

3.10.8.3.3 Overload Protection Location

Overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on-orbit shall be located where they can be seen and replaced or reset without removing other components.

3.10.8.3.4 Overload Protection Identification

Each overload protector (fuse or circuit breaker) intended to be manually replaced or physically reset on-orbit shall be readily identified or keyed for its proper value.

3.10.8.3.5 Automatic Restart Protection

Controls shall be employed that prevent automatic restarting after an overload-initiated Shutdown.

3.10.8.4 Sharp Edges and Corners Protection

Investigation design within a pressurized module shall protect crewmembers from sharp edges and corners during all crew operations. Translation paths and adjacent equipment shall be designed to minimize the possibility of entanglement or injury to crewmembers.

3.10.8.4.1 Holes

Holes that are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in.) shall be covered.

3.10.8.4.2 Latches

Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4 in) exists shall be designed to prevent entrapment of a crewmember’s appendage.

3.10.8.4.3 Screws and Bolts

Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in) shall be capped to protect against sharp threads.

3.10.8.4.4 Securing Pins

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface.

3.10.8.4.5 Levers, Cranks, Hooks, and Controls

Levers, cranks, hooks, and controls shall not be located where they can pinch, snag, or cut the crewmembers or their clothing.

3.10.8.4.6 Burrs

Exposed surfaces shall be free of burrs.

3.10.8.4.7 Lockwire

Investigations shall not use safety/lock wires on any fasteners.

3.10.8.5 Procedural Hazard Controls

Investigations shall be responsible for using crew procedures to control the MSG hazards specified below. Depending on the investigation, some of these hazards may not be applicable.

a. Investigation crew procedures shall have a step(s) that directs the crew to purge the MSG work volume for 2 minutes following the use of the Nitrogen system. If the MSG is in normal mode, then the work volume can be purged by opening a sideport or gloveport. (Reference Payload Hazard Report (PHR) MSG-FL4, control 1)

b. Investigation crew procedures shall have a step(s) that directs the crew to verify all experiment power outlets are OFF prior to any mating/demating of connectors in the work volume. (Reference PHR MSG-G2, control 6.2)

c. Investigation crew procedures shall be written such that any ICP mating occurs prior to experiment activation and any ICP demating occurs after experiment deactivation. (Reference PHR MSG-G2, control 4.3)

d. Investigation crew procedures shall contain the following text whenever the investigation requires the core facility to be extracted or inserted:

   "While holding the MSG Short Handrail with the left hand, use right hand to:
   Push knob, slide Core Facility to retracted (inserted) position.
   Pull knob (secures locking mechanism)
   √Core Facility position securely locked"

   (Reference PHR MSG-G4, control 2.2)

e. Investigation crew procedures shall contain the following text whenever the MSG Airlock door is being opened or closed:

   "MSG AL Front Door left latches (two) → OPEN
   Open MSG AL Front Door (door swings to right)"

   (Reference PHR MSG-G4 control 2.3)

f. Investigation crew procedures shall have a step(s) that instructs the crew to inspect the MSG gloves prior to the start of experiment operations. (Reference PHR MSG-GB1, control 4.3)

g. Investigation crew procedures shall have a step(s) that instruct the crew to insert a closing cap on the MSG glove port should a glove rupture. (Reference PHR MSG-GB1, control 4.5)

h. Investigations shall develop maintenance crew procedures in the event of a material spill or leak. (Reference PHR MSG-GB1, control 11.1)

i. Investigation crew procedures shall have a step(s) that instructs the crew to close the vacuum resource/exhaust valve in the event of leakage of vacuum resource or vacuum exhaust lines. (Reference PHR MSG-GB3, control 3.3)

j. Investigation crew procedures shall have a step(s) that instructs the crew to notify the POIC should any type of leak or spill occur. (Reference PHR MSG-IntFL02, control 1.2 & MSG-Int-FL03, control 1.3)

k. Investigation crew procedures shall be developed for instructing the crew on how to use the investigation clean up equipment. (Reference PHR MSG-Int-FL03, control 1.2)

3.10.9 Payload In-Flight Maintenance

Investigation hardware designed to be maintainable shall use Space Station provided on-board tools. A list of available tools for on-orbit use can be found at:
http://iss-www.jsc.nasa.gov/ss/issapt/opsipt/mresup/mresup_home.html

3.10.10 Deleted

3.10.11 Egress

Investigations egress requirements shall be in accordance with 1700.7, ISS Addendum, paragraph 205.

3.11 Safety

Investigations shall comply with the safety requirements contained in section 4.3 of this document.

The following paragraphs define what data is considered as Health and Status Data and information on the Caution and Warning classifications supported by the MSG C&DH system.

Health and Status Data:

Health and Status data is defined as information that provides the crew and ground confirmation of performance, operational state, resource consumption, and assurance of operating within safety guidelines as defined by the PSRP and the ISS Flight Rules. The MSG provides some insight into the operational state of the investigation via the MSG health and status data, such as the circuit being opened or closed, current being drawn, and WV temperatures.

When required, the investigations needs to send the Safety related data once every second.

Caution and Warning:

For the purpose of C&W classifications, the sensors are the investigations means of detecting events that were deemed necessary by the PSRP during the Phased Safety Reviews. The sensors used to produce Caution and Warning Events are determined by the investigation, advisories may be set if the investigation identifies a situation that meets the classification of an advisory.

Class 1 – Emergency:

All of the defined ISS Emergency conditions are reported by the ISS systems or the rack smoke detector, investigations will not report an Emergency condition.

- The emergency condition rapid cabin depressurization will be detected by the ISS module sensors.
- The emergency condition of toxic atmosphere is set as a scar.
- Payload Fire emergency's can only be declared as a confirmed fire event by the ISS rack smoke detector or equivalent, which can detect 96% of the smoke detector failures.

When an emergency event is detected, the format of the data will identify the event type (fire, toxic atmosphere, depressurization).

Emergency conditions require all onboard crew to respond immediately.

Class 2 – Warning:

Investigations shall format the caution and warning word in accordance with the Experiment Health and Status Data for the SPLC and MLC, of MSG-ORIGIN-IC-0001 as a warning when the investigation sensors detect the following conditions:

a. A potential fire event, (detected by a sensor other than an ISS rack smoke detector or Equivalent)

b. A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization or fire) and

(a) automatic safing has failed to safe the event or
(b) the system is not automatically safed (i.e. requires manual intervention)

c. An event that results in the loss of a hazard control and

(a) automatic safing has failed to safe the event or
(b) the system is not automatically safed (i.e. requires manual intervention)

Note: A Warning requires someone to take action immediately. Warnings are used for events that require manual intervention and for notification when automatic safing fails.

Class 3 – Caution:

Investigations shall format the caution and warning word in accordance with the Experiment Health and Status Data for the SPLC and MLC, of MSG-ORIGIN-IC-0001 as a caution when the investigation sensors detect the following conditions:

a. A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization or fire) and automatic safing has safed the event (i.e. the system does not require manual intervention)

b. An event that results in the loss of a hazard control and automatic safing has safed the event (i.e., the system does not require manual intervention)

Note: A Caution requires no immediate action by the crew. Automatic safing has controlled the event.

Class 4 – Advisory:

Investigations that require an advisory shall format the caution and warning word in accordance with the Experiment Health and Status Data for the SPLC and MLC, of MSG-ORIGIN-IC-0001 as an advisory.

Advisories are set for the following conditions:

a. Advisories are set primarily for ground monitoring purposes (advantageous due to limited comm. coverage and data recording).

b. Data item that most likely will not exist permanently in Telemetry List but should be time tagged and logged for failure isolation, trending, sustaining engineering, etc.

4.0 VERIFICATION

This section comprises a plan for the accomplishment of all MSG interface and identified generic safety verification requirements levied upon the MSG Investigator hardware. These requirements are the basis for a verification program that will demonstrate that the Investigator hardware satisfies performance, functionality, safety, and interface requirements. These verification requirements will ensure the MSG capacity to perform mission objectives both safely and efficiently for International Space Station Increment flights.

Verification activities can include demonstration (functionality / performance), testing, inspection, and analysis, which will be conducted primarily at the Investigators home center. Special verification requirements may be levied, should the Investigation have a unique hazard identified or a direct interface with the ISS Module (i.e. data, power, etc.). Several of the verification requirements will be satisfied with integrated systems level tests (i.e. MSG Engineering Unit plus the Investigators flight hardware in its on-orbit configuration) and will be identified in the Investigation Verification Applicability Matrix. The IDT shall use the ISS Payload Human Engineering Team (IPHET) to closeout selected (not all) Human-Factor requirements in section 3.10. The IPHET will help in the evaluation of the investigation hardware to assess whether operational suitability is met. Some late verification activities may be performed at the Kennedy Space Center (KSC). Within the Verification Applicability Matrix and Verification Definition Sheets, you are referenced to paragraph(s) in this document that detail each requirement. Paragraphs that say **“the Investigator shall”** indicates that the requirement must be verified. Paragraphs that say **“the Investigator will”** are for design information only, and need not be verified. Only the “shall” statements (items that must be verified) are identified in the matrix contained in this document. Verification Definition Sheets (VDS), which define the data required for verification closure of each requirement in the matrix, are included in Appendix E of this document.

Based on the requirements from this document, which are determined by the Investigator to be applicable to their investigation, a similar matrix will be developed and included in the Unique Investigation ICD prepared for that investigation. The Verification Applicability Matrix developed for the Investigation ICD will be a subset of the matrix contained in this document and will include only the requirements applicable to that investigation. The verification items to be included in the Unique Investigation Matrix will be negotiated and approved by the IIT. The approved Investigation Unique Verification Matrix will identify the appropriate VDS number from Appendix E of this document that corresponds to the applicable requirement.

The Investigation Applicability Matrix in the unique Increment Investigation ICD addresses the following areas:

1.0 Structural/Mechanical and Microgravity and Stowage Interface Requirements

2.0 Electrical Interface Requirements
3.0 Command and Data Handling Interface Requirements
4.0 Video and Audio Interface Requirements
5.0 Thermal Control Interface Requirements
6.0 Vacuum System Interface Requirements
7.0 Pressurized Gases Interface Requirements
8.0 Environmental Interface Requirements
9.0 Fire Protection Interface Requirements
10.0 Materials and Parts Interface Requirements
11.0 Human Factors Interface Requirements
12.0 Safety Requirements

4.1 Responsibilities

The MSG Investigation Integration Team is responsible for allocating and tracking the integrated rack level requirements levied on the Investigation Developer, and for performing the integrated system tests required to satisfy ISS verification requirements identified in this IIRD flowed from SSP-57411, MSG Verification Plan. The Investigation Developer is responsible for providing certification of compliance for all applicable verification requirements in this document. Applicable requirements are identified in the Verification Applicability Matrices in the unique Investigation ICD. The Investigation Developer is also responsible for providing all data/test results required in this section. The MSG Integration Team is responsible for review and approval of the verification data required for each investigation.

4.2 Verification Methods

All Investigator hardware interfaces shall be verified by test, analysis, inspection, demonstration, or a combination of these methods. The method(s) of verification for each requirement is identified in Table XXXVI, MSG Investigation Applicability Matrix, and reflects the acceptable method(s) of closure. The methods of verification and minimum criteria for use are defined below.

4.2.1 Analysis

Analysis is a technical evaluation that relates equipment design and use parameters for prediction of actual design and operation. Analysis may be used to verify requirements, provided established techniques used are adequate to yield confidence, or where testing is impractical. Included in this category is analysis of similarity to items previously verified to the same criteria or more stringent criteria. Verification accomplished by analysis shall be evidenced by an analysis report.

4.2.2 Test

Test is actual operation of equipment under simulated conditions or the subjection of equipment to specified environments to measure responses. When analysis or inspection is specified as the method of verification, testing may be used to satisfy the requirement if preferred by the hardware developer, if it is cost effective, and if the Microgravity Science Glovebox Integration Manager agrees. Verification accomplished by test shall be evidenced by a test report.

4.2.3 Inspection

Inspection is a physical evaluation of equipment and associated documentation. Inspection may be used to verify construction features, drawing compliance, workmanship, and physical condition. It includes determination of physical dimensions. Verification accomplished by inspection shall be evidenced by an inspection report.

4.2.4 Demonstration

Demonstration is the qualitative determination of compliance with requirements by observation during actual operation or simulation under preplanned conditions and guidelines. Some human factor requirements were the method of closure is a demonstration requires the investigation to be set up in its on-orbit configuration in the EU to verify that the requirement is satisfied.

4.3 Safety Verification Requirements

4.3.1 Flight

Safety requirements are found in NSTS 1700.7, Safety Policy and Requirements for Payloads Using the Space Transportation System and NSTS 1700.7 ISS Addendum, Safety Policy and Requirements for Payloads Using the International Space Station. Information on Payload Safety Reviews and required data is found in NSTS 13830, Payload Safety Review and Data Submittal Requirements. The investigator shall submit safety verification data as specified by the investigator developed payload hazard reports. Table XXXVI, MSG Investigation Applicability Matrix, lists safety related requirements applicable to standard (generic) hazards as defined in JSC Form 1230 as well as two unique hazards that may be applicable to most investigations (release of experiment materials and pressurized lines, fittings, and components). Verification data must reflect the as-built configuration and provided for all flight hardware and flight backup hardware. For payloads that have previously flown as STS payloads, verification requirements will be developed using the guidelines established by the baselined payload hazard reports and will include safety impact of any design changes from the baseline mission. For new payloads, verification requirements will be developed based on JSC Form 1230 and payload unique hazard reports (if any).

4.3.2 Ground

Ground safety requirements are found in KHB 1700.7, Space Shuttle Payload Ground Safety Handbook. Information on Ground Safety Reviews and required data is found in NSTS 13830, Payload Safety Review and Data Submittal Requirements. The investigator shall submit ground safety verification data as specified by the investigator developed ground safety hazard reports.

4.3.3 General

This IIRD is intended to summarize safety verification data required to satisfy the NSTS payload safety review process. However, verification requirements may change as a normal result of this process, and in such cases the MSG Investigation Applicability Matrix be amended to reflect results of the safety review process.. The ultimate source for payload specific safety verification data will be signed Phase III payload hazard reports for new payloads or Phase III approved reverification matrix for reflight payloads.

5.0 VERIFICATION APPLICABILITY MATRIX

5.1 Purpose

The Investigator Verification Applicability Matrix, Table XXXVI, lists the Microgravity Science Glovebox Investigation Integration Team Interface and Safety Verification Requirements for Investigator hardware with associated verification methods. The Applicable(A) or Non-Applicable(N/A) and a schedule for data submittal of each hardware element will be developed on a case-by-case basis.

Definitions of Column Headings for Verification Requirements Table XXXVI

Requirement Number	Identifies verification requirements by number and the item status is tracked by using this number.
Requirement Title	Identifies the requirement.
Safety Related	Identifies those items required to satisfy a Hazard control.
MSG IIRD Paragraph	Defines the interface being used and the verification activity required for use of that interface.
Verification Method(s)	Defines the method(s) required to perform the verification function.
Hardware Item(s)	Defines each hardware element (i.e. Exp. Control Box, Exp. Sample Container, etc.) and its applicability to the requirement.
Due Date	Defines the date that the verification package is due to the Integration Manager.
Remarks	Defines the Verification Data Sheet number or if it is a PSRP/Safety requirement.

Table XXXVI, MSG Investigation Applicability Matrix, identifies three items relevant to each verification requirement and hardware element. The items identified are: (1) the method(s) of verification, or the acceptable certification, if allowed. Acceptable methods of verification are denoted by: Analysis (“A”), Test (“T”), Integrated testing with the MSG Engineering Unit (T*) the IDT is not responsible for submitting this test data, Inspection (“I”), and Demonstration (D), Integrated demonstration with the MSG Engineering Unit (D**) the Lead Test Engineer shall provide the test results to Lead Systems Engineer. The requirements that have (PSRP) in the methods column are included for completeness of the design requirements. It is the responsibility of the Investigation to address these requirements through the PSRP. For a more detailed description of the methods and certifications, see Section 4.2, Verification Methods. (2) The date that the verification data is due. The due date is agreed to by both the Investigator and the MSG Integration Manager. (3) The applicable Verification Data Sheet associated with the requirement number.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.1.1.1.c & d	Loads Requirements	Yes (d)	3.1.1.3 (3.4.1 Middeck IDD)	A			L-8	ST-001 & ST-002
3.1.1.2.a & b	Additional Requirements		3.1.1.2. B (6.1 Middeck IDD)	T & A			L-8	ST-003 & ME-001
3.1.1.3	Attachment Provisions (fit check & integrated test with facility)			T & I	*	*	L-20 L-9	ME-046
3.1.2.1	Quasi-Steady Requirements		3.1.2.1	T or A			L-8	EN-005
3.1.2.2	Vibratory Requirements		3.1.2.2	T or A			L-8	EN-005
3.1.2.3	Transient Requirements		3.1.2.3	T or A			L-8	EN-005
3.1.2.5	Angular Momentum Limits		3.1.2.5	NVR or A			L-8	EN-005
3.1.3	Stowage Input Requirements (Weight, cg & Geometry)		3.1.3 (3.4.1 & 4.8.1 Middeck IDD)	T & A			L-8	ME-001
3.2.1.a & b	Electrical Power Characteristics (Power Draw)		3.2.1	T & A			L-8	EL-006 Closed prior to integration testing
3.2.1.1	Steady-State Voltage Characteristics		3.2.1.1	T			L-9.5	EL-001 Closed prior to integration testing
3.2.1.2.1	Ripple Voltage and Noise	Yes	3.2.1.2.1	A			L-10	EL-002
3.2.1.2.2	Ripple Voltage Spectrum	Yes	3.2.1.2.2	A			L-10	EL-002

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.2.1.3	Transient Voltages		3.2.1.3.1	T or A			L-8	EL-003
3.2.1.3.1.a & b	Fault Clearing and Protection		3.2.1.3.3	A			L-8	EL-004
3.2.1.3.2	Non-Normal Voltage Range		3.2.1.3.4	A			L-8	EL-005
3.2.2.1.b, c, d	Primary Power Connector			D & I			L-8	EL-007 Closed prior to integration testing
3.2.2.2.b, c, d	Secondary Power Connector			D & I			L-8	EL-007 Closed prior to integration testing
3.2.2.3.a, b	Surge Current		3.2.2.4	T & A	*	*	L-10	EL-010
3.2.2.4	Reverse Current		3.2.2.5	A			L-10	EL-011
3.2.2.5.a,b,c & d	Circuit Protection Devices	Yes	3.2.2.6	A			L-8	EL-012
3.2.2.6	Deleted		3.2.2.9					
3.2.2.7	Investigation Complex Load Impedance		3.2.2.7.2	T	*	*	L-10	EL-014
3.2.2.8	Large Signal Stability		3.2.2.8	A & T	*	*		EL-023
3.2.2.9	Electrical Load-Stand Alone Stability		3.2.210	A			L-10	EL-016
3.2.3.1	Wire Derating	Yes	3.2.3.1	A			L-8	EL-017
3.2.3.2	Loss of Power	Yes	3.2.3.3	T (PSRP)			L-8	Safety
3.2.4	Electromagnetic Compatibility	Yes	3.2.4	T & A			L-10	EL-020
3.2.4.1.a – e thru 3.2.4.1.2.7	Electrical Grounding/Isolation	Yes	3.2.4.1	T & A			L-10	EL-020 & EL-021 Closed prior to integration testing
3.2.4.2 thru 3.2.4.2.6.3.2	Electrical Bonding	Yes	3.2.4.2	T & I & A	*	*	L-10	EL-020 & EL-022

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.2.4.3.1.2.1.3	Shield Grounding Requirements	Yes	3.2.4.3	T & I & A			L-10	EL-021
3.2.4.3.1.2.4	Shields		3.2.4.3	A & I			L-10	EL-021
3.2.4.3.1.2.4.1	Terminations		3.2.4.3	A & I			L-10	EL-021
3.2.4.3.1.2.4.3	Grounding of Radio Frequency Circuit Shields		3.2.4.3	A			L-10	EL-021
3.2.4.3.1.2.4.4	Internal Equipment Shields		3.2.4.3	A			L-10	EL-021
3.2.4.3.1.2.4.5	Grounding		3.2.4.3	A			L-10	EL-021
3.2.4.4 thru 3.2.4.4.2.6	Electrormagnetic Emission and Susceptibility Requirements	Yes	3.2.4.4	T & A			L-10	EL-020
3.2.4.5	Electrostatic Discharge	Yes	3.2.4.5 (8.4.1.2.3.1 Middeck IDD)	A&I or T & I			L-10	EL-024
3.2.4.6	Alternating Current Magnetic Fields	Yes	3.2.4.6	T or A			L-10	EL-020
3.2.4.7	Direct Current Magnetic Fields	Yes	3.2.4.7	T &A			L-10	EL-020
3.2.4.8	Deleted							
3.2.5.1	Mating/Demating of powered connectors	Yes	3.2.5.1.1	I (PSRP)			L-8	Safety
3.2.5.2	Safety-Critical Circuits Redundancy	Yes	3.2.5.1.2	A (PSRP)			L-8	Safety
3.2.5.3.a	Power Switches/Controls	Yes	3.2.5.3.A	A			L-8	EL-029
3.2.5.3.b	Power Switches/Controls	Yes	3.2.5.3.B	A			L-8	EL-029
3.2.5.3.c	Power Switches/Controls	Yes	3.2.5.3.C	A			L-8	EL-029
3.2.5.4.a - g	Deleted							
3.2.5.5.a,b	Deleted							
3.3	Command and Data Handling Requirements							

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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3.3.1.1.1	RS422 Cable Characteristics			I			L-9.5	CD-01 Closed prior to integration testing
3.3.1.1.2	WV RS-422 Interface Connector/Pin Assignments			I			L-9.5	CD-01 Closed prior to integration testing
3.3.1.1.3	RS-422 Signal Characteristics			I			L-9.5	CD-01 Closed prior to integration testing
3.3.1.1.4	RS-422 Port Settings			I			L-9.5	CD-01 Closed prior to integration testing
3.3.1.2.1	RS-422 Protocols							
3.3.1.2.1.1	RS-422 Byte and Bit Order			T	*	*	L-9	CD-02
3.3.1.2.1.2	RS-422 word Alignment			T	*	*	L-9	CD-02
3.3.1. 2.1.3	ESTEC Data Link Format (EDLF)			T	*	*	L-9	CD-02
3.3.1. 2.1.4	RC Required Headers			T	*	*	L-9	CD-02
3.3.1.2.2.1.1	RS-422 Experiment Commands			T	*	*	L-9	CD-02
3.3.12.2.1.2	Time of Day (TOD) Data			T	*	*	L-9	CD-02
3.3.1.2.2.1.3	RS-422 File Transfers, RC to WV			T	*	*	L-9	CD-02
3.3.1.2.2.2.1	RS-422 Command Acknowledges			T	*	*	L-9	CD-02

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.3.1.2.2.2.2	RS-422 Experiment Health and Status			T	*	*	L-9	CD-02
3.3.1.2.2.2.3	RS-422 Experiment Low Rate Telemetry			T	*	*	L-9	CD-002
3.3.1.2.2.2.4	RS-422 File Transfers, WV to RC			T	*	*	L-9	CD-02
3.3.1.2.2.2.5	RS-422 Log Messages			T	*	*	L-9	CD-02
3.3.1.2.2.2.6	RS-422 MSG Video Commands			T	*	*	L-9	CD-02
3.3.2	Investigation I/O Interface							
3.3.2.1.1	I/O Cable Characteristics			I			L-9.5	CD-03 Closed prior to integration testing
3.3.2.1.2	I/O Connector/Pin Assignments			I			L-9.5	CD-03 Closed prior to integration testing
3.3.2.1.3	I/O Signal Characteristics			T			L-9.5	CD-03 Closed prior to integration testing
3.3.2.2.2	I/O Configuration and Control Commands			T	*	*	L-9	CD-04
3.3.3	MLC Serial Interface							

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.3.3.1.1	MLC Cable Characteristics			I			L-9.5	CD-05 Closed prior to integration testing
3.3.3.1.2.1	MLC Outside the Work Volume			I			L-9.5	CD-05 Closed prior to integration testing
3.3.3.1.2.2	MLC Inside the Work Volume			I			L-9.5	CD-05 Closed prior to integration testing
3.3.3.1.3	MLC Signal Characteristics			I			L-9.5	CD-05 Closed prior to integration testing
3.3.3.1.4	MLC Serial Interface Port Settings			I			L-9.5	CD-05 Closed prior to integration testing
3.3.3.2	MLC Serial Interface Software Requirements			T	*	*	L-9	CD-06
3.3.4	MLC Ethernet Interface							
3.3.4.1.1	MLC Ethernet Cable Characteristics			I			L-9.5	CD-07 Closed prior to integration testing
3.3.4.1.2	MLC Ethernet Connector / Pin Assignments			I			L-9.5	CD-07 Closed prior to integration testing

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.3.4.1.3	MLC Ethernet Signal Characteristics			I			L-9.5	CD-07 Closed prior to integration testing
3.3.4.2	MLC Ethernet Software Requirements			T	*	*	L-8	CD-08
3.3.5	MLC Software Interface							
3.3.5.1	MLCS RS232 Interface			T	*	*	L-8	CD-09
3.3.5.2	MLCS Ethernet Interface			T	*	*	L-8	CD-09
3.3.5.3	MLCS Socket Interface			T	*	*	L-8	CD-09
3.3.6	ISS LAN1/LAN2 Interface							
3.3.6.1.1	Ethernet Interface Cable Characteristics		3.3.6.1.6	I			L-9.5	CD-012 Closed prior to integration testing
3.3.6.1.2	Ethernet Interface Connector / Pin Assignments			I			L-9.5	CD-012 Closed prior to integration testing
3.3.6.1.3	Ethernet Interface Signal Characteristics		3.3.6.1.5	I&T			L-9.5	CD-012 Closed prior to integration testing
3.3.6.1.4	Connectivity		3.3.6.1.3	I&T			L-9	CD-011
3.3.6.2.1	Protocol		33.6.1	T			L-9.5	CD-010 Closed prior to integration testing

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.3.6.2.2	Address		3.3.6.1.2	A&T			L-9	CD-011
3.3.7	Video Interface							
3.3.7.1.1	Video Interface Cable Characteristics			T&I			L-9.5	CD-013 Closed prior to integration testing
3.3.7.1.2	Video Interface Connector / Pin Assignments			I			L-9.5	CD-013 Closed prior to integration testing
3.3.7.1.3	Video Interface Signal Characteristics			T			L-9.5	CD-013 Closed prior to integration testing
3.3.7.2.1	Video Interface Commands			T	*	*	L-8	CD-14
3.4.1.1	WV Air Circulation System			A			L-8	FD-002
3.4.1.2.1.a - d	Investigation Coldplate Mounting Requirements			I & A			L-9 L-8	FD-003
3.4.1.4	Loss of MSG Cooling or Services	Yes		A			L-8	FD-004
3.5.1.1.a - f	VES Physical Interface		3.6.1.1	D & T			L-8	FD-014
3.5.1.2.a, b, c	VES Input Pressure Limit	Yes	3.6.1.2	T & A			L-8	FD-015
3.5.1.3	VES Input Temperature Limit		3.6.1.3	T			L-8	FD-016
3.5.1.4	VES Input Dewpoint Limit		3.6.1.4	T			L-8	FD-017
3.5.1.5.a - d	VES Acceptable Exhaust Gases	Yes	3.6.1.5	A or A&T			L-20 L-12	FD-018
3.5.1.5.2.a - e	VES External Contamination Control		3.6.1.5.2	A			L-20 L-12	FD-019
3.5.1.5.3	Deleted							
3.5.2.1.a - e	VRS Physical Interface			T & D			L-8	FD-021

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.5.2.2.a, b, c	VRS Input Pressure Limit	Yes	3.6.2.2	A & T			L-8	FD-022
3.5.2.3	VRS Through-Put Limit		3.6.2.3	T			L-8	FD-023
3.6.1.1.a	Nitrogen Physical Interface		3.7.1	I			L-8	FD-027
3.6.1.1.b	Nitrogen Leakage		3.7.1.4	T			L-8	FD-027
3.6.1.2	Nitrogen Flow Control		3.7.1.1	T			L-8	FD-024
3.6.1.3	Nitrogen Interface MDP	Yes	3.7.1.2	A&T			L-15 L-12	FD-025
3.6.1.4	Nitrogen Interface Temperature		3.7.1.3	NVR			L-8	
3.6.1.5 a - e	Nitrogen Operational Constraints	Yes		I				FD-024
3.6.2	Pressurized Gas Bottles	Yes	3.7.5	A			L-8	FD-028
3.7.1.1	Pressure	Yes	3.9.1.1	A or T (PSRP)			L-8	Closed when hazard report app.
3.7.1.2	Temperature	Yes	3.9.1.2	A or T (PSRP)			L-8	Closed when hazard report app.
3.7.1.3	Humidity		3.9.1.3	A			L-8	EN-001
3.7.2.3.1.a - f	ICP Outlet Interface Requirements			D & I & T			L-8	EL-037
3.7.3.a - f	WV Environment			A or T			L-8	EN-007 MP-004 for c
3.7.4.1	Active Air Exchange		3.9.2.1.A	I			L-8	EN-002
3.7.4.2	Oxygen Consumption		3.9.2.2	A			L-8	EN-003
3.7.4.3	Chemical Releases	Yes	3.9.2.3	A & I (PSRP)			L-8	Closed when hazard report app.

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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3.7.4.4	Cabin Air Heat Leak		3.5.1.12	A			L-8	EN-002
3.7.5.1	Investigation Containing or Generated Ionizing Radiation		3.9.3.1	A (PSRP)			L-8	Closed when hazard report app.
3.8	Fire Protection Interface Requirements	Yes	3.10.1	A (PSRP)			L-8	Closed when hazard report app.
3.8.1.1.a - e	Investigation Monitoring and Detection	Yes	3.10.2.2.2.1	T (PSRP)			L-8	Closed when hazard report app. Or CD-02 if applicable
3.8.1.2.a, b, c	Investigation Fire Suppression	Yes	3.10.3	A & I&D			L-8	ME-055
3.9.1	Materials and Parts Use and Selection	Yes	3.11.1	A & I (PSRP)			L-8	Closed when hazard report app.
3.9.1.1	Deleted		3.11.1.1					
3.9.1.2.a - g	Additional Material Requirements	Yes	3.11.4	A, I & T			L-20 L-12 L-8	MP-003 (for e), MP-004
3.9.2	Cleanliness		3.11.3 (5.1 Middeck IDD)	I			L-8	MP-002
3.10.1.a, b, c	Strength Requirements		3.12.1.A	A or D (IPHET)			L-8	ST-005
3.10.2.1.1	Closures or Covers		3.12.3.1.1	I (IPHET)			L-8	ME-007
3.10.2.1.2.a	Built-In Control	Yes	3.12.3.1.2.A	I (IPHET)			L-8	ME-008
3.10.2.1.2.b	Built-In Control	Yes	3.12.3.1.2.B	A or D (IPHET)			L-8	ME-008

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

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3.10.2.1.3	One-handed Operation		3.12.3.1.5	D (IPHET)			L-8	ME-009
3.10.2.2.1	Continuous/Incidental Contact-High Temperature	Yes	3.12.3.2.1	A (PSRP)			L-8	Closed when hazard report app.
3.10.2.2.2	Continuous/Incidental Contact-Low Temperature	Yes	3.12.3.2.2	A (PSRP)			L-8	Closed when hazard report app.
3.10.2.2.3.a	Acoustic Requirements		3.12.3.3.1. C	T			L-10	EN-006
3.10.2.2.3.b	Intermittent Noise Limits		3.12.3.3.2	T			L-10	EN-006
3.10.2.2.4	Lighting Design		3.12.3.4. C	D (IPHET)			L-8	ME-043
3.10.3.1	Equipment Mounting		3.12.4.2.1	A or D (IPHET)			L-8	ME-011
3.10.3.2	Unique Tools		3.12.4.2.8. 4	A			L-8	ME-016
3.10.3.3	Connectors		3.12.4.3					
3.10.3.3.1	One-Handed Operation		3.12.4.3.1	D (IPHET)	**	**	L-8	ME-017
3.10.3.3.2	Connector Accessibility		3.12.4.3.2. A, B	D (IPHET)	**	**	L-8	ME-018
3.10.3.3.3	Connector Ease of Disconnect		3.12.4.3.3	A (IPHET)			L-8	ME-017
3.10.3.3.4	Connector Self Locking	Yes	3.12.4.3.5	A (IPHET)			L-8	ME-017
3.10.3.3.5	Connector Arrangement		3.12.4.3.6 A, B	I (IPHET)	**	**	L-8	ME-018
3.10.3.3.6	Connector Arc Containment	Yes	3.12.4.3.7	A			L-8	EL-026
3.10.3.3.7	Connector Protection	Yes	3.12.4.3.8	A			L-8	ME-019
3.10.3.3.8	Connector Shape		3.12.4.3.9	A (IPHET)			L-8	ME-019
3.10.3.3.9	Fluid and Gas Line Connectors	Yes	3.12.4.3.10	A (IPHET)			L-8	FD-001

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.10.3.3.10	Connector Coding		3.12.4.3.12 A, B	I			L-8	ME-020
3.10.3.3.11	Connector Pin Identification		3.12.4.3.13	I (IPHET)			L-8	EL-007
3.10.3.3.12	Connector Orientation		3.12.4.3.14	A (IPHET)			L-8	ME-020
3.10.3.3.13	Alignment Marks or Guide Pins		3.12.4.3.11 .A	I (IPHET)	**	**	L-8	ME-020
3.10.3.4	Fasteners		3.12.4.4					
3.10.3.4.1	Non-Threaded Fasteners Status Indication		3.12.4.4.1	D or I (IPHET)			L-8	ME-023
3.10.3.4.2	Mounting Bolt/Fastener Spacing		3.12.4.4.2	I (IPHET)	**	**	L-8	ME-024
3.10.3.4.3	Multiple Fasteners		3.12.4.4.4. A	I (IPHET)			L-8	ME-025
3.10.3.4.4	Captive Fasteners		3.12.4.4.5	A (IPHET)			L-8	ME-026
3.10.3.4.5	Quick Release Fasteners		3.12.4.4.6. A,B	I (IPHET)			L-8	ME-026
3.10.3.4.6	Threaded Fasteners		3.12.4.4.7	I (IPHET)			L-8	ME-026
3.10.3.4.7	Over Center Latches		3.12.4.4.8. A, B, C	I (IPHET)			L-8	ME-027
3.10.3.4.8	Winghead Fasteners		3.12.4.4.9	I (IPHET)			L-8	ME-026
3.10.3.4.9	Fastener Head Type		3.12.4.4.11 .A, B, C	I (IPHET)			L-8	ME-028
3.10.3.4.10	One-Handed Actuation		3.12.4.4.12	D (IPHET)	**	**	L-8	ME-029
3.10.3.4.12	Fastener Access Holes		3.12.4.4.14	I (IPHET)			L-8	ME-024
3.10.4	Controls and Displays		3.12.5	I (IPHET)			L-8	
3.10.4.1	Controls Spacing Design Requirements		3.12.5.1	I (IPHET)			L-8	ME-030
3.10.4.2.a, b, c	Actuation Protective Methods		3.12.5.2.1. B, C, D	I (IPHET)			L-8	ME-031
3.10.4.3	Controls Noninterference		3.12.5.2.2	I (IPHET)			L-8	ME-030

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.10.4.4	Controls Barrier Guards		3.12.5.2.4	I (IPHET)			L-8	ME-030
3.10.4.5	Recessed Switch Protection		3.12.5.2.5	I (IPHET)			L-8	ME-031
3.10.4.6	Controls Position Indication		3.12.5.2.7	I (IPHET)			L-8	ME-032
3.10.4.7	Hidden Controls		3.12.5.2.8	I (IPHET)			L-8	ME-031
3.10.4.8	Hand Controllers		3.12.5.2.9	I (IPHET)			L-8	ME-031
3.10.4.9.a - e	Valve Controls		3.12.5.3.A - E	I (IPHET)			L-8	ME-033
3.10.4.10	Toggle Switches		3.12.5.4	I (IPHET)			L-8	ME-034
3.10.5.1.a, b, c	Stowage Container Contents Restraints		3.12.6.1.A, B, C	A & I (IPHET)			L-8	ME-036
3.10.5.2.a & b	Stowage and Equipment Container/Trays		3.12.6.2.A & B	I (IPHET)			L-8	ME-027
3.10.5.3	Captive Parts		3.12.6.3	I (IPHET)			L-8	ME-036
3.10.5.4	Handles		3.12.6.4.1	I & A (IPHET)			L-8	ME-037
3.10.5.5	Handle Location/Front Access		3.12.6.4.3	I (IPHET)			L-8	ME-037
3.10.6	Handle Dimensions		3.12.6.4.4	D or I (IPHET)			L-8	ME-037
3.10.7	Identification Labeling		3.12.7, 3.10.4.A & B	I			L-8	ME-057
3.10.8.1.a	Deleted							
3.10.8.1.b	Deleted							
3.10.8.1.c	Deleted							
3.10.8.1.d	Deleted							
3.10.8.1.e	Deleted							
3.10.8.2	Mismatched	Yes	3.12.9.1.1	I or D (IPHET)			L-8	ME-019
3.10.8.3.1	Device Accessibility		3.12.9.1.4.1	I (IPHET)			L-8	EL-013

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Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.10.8.3.2	Extractor – Type Fuse Holder		3.12.9.1.4.2	D (IPHET)			L-8	EL-013
3.10.8.3.3	Overload Protection Location		3.12.9.1.4.3	I (IPHET)			L-8	EL-013
3.10.8.3.4	Overload Protection Identification		3.12.9.1.4.4	I (IPHET)			L-8	EL-013
3.10.8.3.5	Automatic Restart Protection		3.12.9.1.4.5	A (IPHET)			L-8	EL-013
3.10.8.4	Sharp Edges and Corners Protection	Yes	3.12.9.2	I (PSRP) (IPHET)			L-8	Closed when hazard report app. or IPHET app.
3.10.8.4.1	Holes	Yes	3.12.9.3	A & I (IPHET)			L-8	ME-007
3.10.8.4.2	Latches	Yes	3.12.9.4	I (IPHET)			L-8	ME-027
3.10.8.4.3	Screws and Bolts	Yes	3.12.9.5	A & I (IPHET)			L-8	ME-026
3.10.8.4.4	Securing Pins	Yes	3.12.9.6	A (IPHET)			L-8	ME-053
3.10.8.4.5	Levers, Cranks, Hooks, and Controls	Yes	3.12.9.7	A & I (IPHET)			L-8	ME-053
3.10.8.4.6	Burrs	Yes	3.12.9.8	I (IPHET)			L-8	ME-053
3.10.8.4.7	Lockwire	Yes	3.12.9.9.A	A or I (IPHET)			L-8	ST-009
3.10.8.5.a - .k	Procedural Hazard Controls	Yes		I				CP-001
3.10.9	Payload In-Flight Maintenance		3.12.10	A (IPHET)			L-8	ME-003
3.10.10.a	Deleted							
3.10.10.b	Deleted							
3.10.10.c	Deleted							
3.10.11	Egress	Yes	3.12.9.12	(PSRP) (IPHET)			L-8	Closed when hazard report app. or IPHET app.

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

Table XXXVI MSG INVESTIGATION APPLICABILITY MATRIX

MSG IIRD Reqmt. No.	Requirement Statement	Safety	Ref. Reqmt. No. (SSP-57000)	Verif. Method(s)	HDW #1	HDW #2	Due Date	Remarks/ IIT VDS #
3.11	Safety	Yes		(PSRP)			L-8	Closed when hazard reports app.
C.3.5.11	Bar Coding			I			L-8	ME-041

Legend: A – Analysis (when in verification method column), A – Applicable (when used in hardware column), D – Demonstrate, I – Inspection, N/A – Not Applicable NVR, – No verification required, PSRP – Payload Safety Review Panel, T – Test, * Must test with EU, test results to be provided to lead systems engineer. ** Must close with investigation set up in EU.

5.2 Schedule

The schedule for data submittal will be established on a case-by-case basis. The reports and supporting data for the requirements listed in Table XXXVI shall be submitted as they become available but no later than the due dates agreed upon by the Investigator and Microgravity Science Glovebox Investigation Integration Manager identified in the Verification Matrix.

5.3 Reflight Verification

Investigator hardware that have previously flown on ISS increments and that are scheduled for reflight must undergo an assessment for certification. If the reflight design, operations, and environmental criteria are identical and the data provided for the original flight remain valid, then the requirements may be met by submitting a Reflight Certification as detailed below. Any changes in the design, operations, or environments will require the submission of the appropriate data as documented in Table XXXVI and as described in Section 5.4, Verification Results Reporting.

Some reflight verification requirements require an environmental assessment. The Investigator will be requested to perform the assessment and submit the data required to close the verification requirement.

Additionally, all hazard report control verifications from the previous flight must be assessed for applicability. The assessment must consider modifications or maintenance that could affect safety and limited-life items such as gaskets, seals, or batteries.

5.3.1 Reflight Certification

A Reflight Certification is a memorandum from an Investigator certifying that no changes have been made to the hardware components or subsystems since the previous increment(s) which affect that verification data submitted, and that the data will satisfy this verification requirement. The Investigator may submit this in table form. Section 5.5 contains an example of the format.

5.4 Verification Results Reporting

Results of verification activity by analysis, test, inspection and/or demonstration as required herein shall be documented. Also, data submittal shall be as specified in this document. Supporting documentation shall be retained and provided upon request. Detailed analyses and test data shall be submitted as specified herein. All verification data shall be submitted per Investigation Integration Plan, MSFC-PLAN-3052

APPENDIX A
ABBREVIATIONS/ACRONYMS

A	Ampere(s)
AAA	Avionics Air Assembly
ACS	Air Circulation System
APC	Automatic Pressure Control
AC	Alternating Current
AHU	Air Handling Unit
AL	Air Lock
ASDA	American Smoke Detection Assembly
ASW	Application Software
AWG	American Wire Gage
BSW	Basic Software
BSP	Board Support Package
BWAD	Bridge Wire Activated Devise
C	Celsius
cc	Cubic Centimeter
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
C&DH	Command and Data Handling
CE	Conducted Emissions
CF	Core Facility
Cm	Centimeter
CMP	Control & Monitoring Panel
CO	Carbon Monoxide
CO2	Carbon Dioxide
COC	Certificate of Compliance
COF	Columbus Orbiting Facility
COTS	Commercial Off The Shelf
CRES	Corrosion Resistant Steel
CS	Conducted Susceptibility
CSP	Customer Support Plan
CTS	Clear To Send
CUT	Cable Under Test
CVIT	Common Video Interface Transmitter
DC	Direct Current
DB	Decibels
DDCU	DC to DC Converter Unit
DDPF	Decal Design and Production Facility
DHS	Data Handling System
E-Box	Electronic Box
ECB	Experiment Control Board
EDLF	ESTEC Data Lind Format

EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMEEC	Electromagnetic Effects Control
EMI	Electromagnetic Interference
EO	Arbitrary nomenclature to Define Circuit
EPCE	Electrical Power Consuming Equipment
EPP	Enhanced Parallel Port
EPS	Electrical Power System
ESA	European Space Agency
ESD	Electrostatic Discharge
ESEM	Exchangeable Standard Electronic Module
ESTEC	European Space (Research and) Technology Center
EU	Engineering Unit
EUT	Equipment Under Test
EVA	Extravehicular Activity
F	Fahrenheit
FET	Field Effect Transistor
FO	Arbitrary nomenclature to Define Circuit
FTP	File Transfer Protocol
G	Giga
FU	Flight Unit
GFCI	Ground Fault Circuit Interrupter
GHz	Giga Hertz
GU	Ground Unit
HEPA	High-Efficiency Particle Air
HO	Arbitrary nomenclature to Define Circuit
Hz	Hertz
ICP	Internal Control Panel
ICD	Interface Control Document
ID	Identification/Data
IDD	Interface Definition Document
IEEE	Institute of Electrical and Electronic Engineers
IEC	International Electro Technical Commission
IF	Intravehicular Activity
IIT	Investigation Integration Team
IMS	Inventor Management System
I/O	Input/Output
IPLAT	ISS Payload Label Approval Team
IRD	Interface Requirements Document
ISIS	International Subrack Interface Specification
ISPR	International Standard Payload Rack
ISR	Interrupt Service Routine
ISS	International Space Station
IPHET	ISS Payload Human Engineering Team

IVA	Intravehicular Activity
JSC	Johnson Space Center
KB/S	Kilo Bits per Second
KSC	Kennedy Space Center
kg	kilo-grams
kHz	kelo Hertz
Kpa	kelo Pascal
LAN	Local Area Network
lbm	pounds mass
lbs	pounds
lb-s	pound per second
LE	Leakage Emissions
LISN	Line Impedance Stabilization network
LRD	Low Rate Data
LRDL	Low Rate Data Link
LSE	Laboratory Support Equipment
mA	milli-Ampere(s)
MAC	Media Access Control
MAPTIS	Materials and Process Technical Information System
MB/S	Mega Bits per Second
MDM	Multiplexer/Demultiplexer
MDP	Maximum Design Pressure
MHz	Mega Hertz
min	Minute
mm	milli-meter
ML	Arbitrary nomenclature to Define Circuit
MLC	MSG Laptop Computer
MLCS	MLC Server
MO	Arbitrary nomenclature to Define Circuit
MRDL	Medium Rate Data Link
ms	Milli Second
m/s	Meter per second
MPG	Multiple Point Grounding
mVpp	milli-Volts peak to peak
MPLM	Multi-Purpose Logistics Module
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
NASA	National Aeronautics and Space Administration
NASDA	Nation Space Development Agency Japan
NC	Not Connected
N-m	Newton meter
N-s	Newton second
NSTS	National Space Transportation System
NTSC	National Television Standard Committee

ORU	Orbital Replacement Unit
Pa	Pascal
PCS	Portable Computer System
PD	Payload Developer
PDC	Power Distribution & Conversion Box
PFE	Portable Fire Extinguisher
PMMA	Poly Methyl Meth-acrylate
PRCU	Payload Rack Checkout Unit
Psia	Pound per Square inch Atmospheric
Psi	Pound per Square inch
PSRP	Payload Safety Review Panel
PTR	Payload Training Representative
PTCS	Payload Test Checkout System
QD	Quick Disconnect
RC	Rack Controller
RE	Radiated Emissions
RF	Radio Frequency
RFI	Radio Frequency Interference
rms	Root Mean Square
RMSA	Rack Maintenance Switch Assembly
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPSA	Remote Power Switch Assembly
RS	Radiated Susceptibility
RSS	Root-Summed Squared
RTN	Return
RTS	Request to Send
SAMS	Space Acceleration Measurement System
SD	Standard Deviation
scc	Standard Cubic Centimeter
Sec	Second
SEE	Single Event Effect
SPDA	Secondary Power Distribution Assembly
SPL	Sound Pressure Level
SPLC	Standard Payload Computer
SPOE	Standard Payload Outfitting Equipment
SPP	Standard Parallel Port
SSP	Space Station Program
SSPC	Solid State Power Controller
STS	Space Transportation System
TBC	To Be Confirmed
TBD	To Be Determined
TBR	To Be Resolved
TM	Technical Memo
TOD	Time of Day

TU	Training Unit
TWS	Twisted Shield
TWDS	Twisted Double Shield
UART	Universal Asynchronous Receiver-Transmitter
UF-3	Utilization Flight Three
UIPS	Utility Interface Panels
*u*s	Microsecond
USL	United States Laboratory
USOS	United States on-orbit Segment
V	Voltage
VC-S	Visibly Clean - Sensitive
VDC	Voltage Direct Current
VES	Vacuum Exhaust System
VD	Video Drawer
VRS	Vacuum Resource System
Vpp	Volts peak-to-peak
VTVM	Vacuum Tube Voltmeter
WV	Work Volume
Y/C	Luminance/Chrominance

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Appendix B
Electromagnetic Test Techniques

B.0 Requirements

The test techniques and procedures contained in this Appendix shall be used in demonstrating compliance with emission and susceptibility requirements of Section 3.2.4.4. The test levels and test limits are defined in Section 3.2.4.4.

B.1 General Requirements

B.1.1 Test Conditions

B.1.1.1 Ambient Electromagnetic Levels

Conducted and radiated ambient levels shall be at least 6 decibels (dB) below the applicable limits of Section 3.2.4.4. Ambient conditions shall be determined prior to the beginning of measurements on the energized Equipment Under Test (EUT).

B.1.1.2 Ground Plane

A solid plate copper or brass ground plane shall be used. It shall have a minimum thickness of 0.25 millimeter (mm) for copper or 0.63 mm for brass and be 2.25 square meters (m) or larger in area with the smaller side no less than 76 centimeters (cm) in length. When testing is performed in a shielded enclosure, the ground plane shall be bonded to the shielded room such that the direct current (dc) bonding resistance shall not exceed 2.5 milliohms. In addition, the bonds shall be placed at distances no greater than 90–cm apart. For large equipment mounted on a metal test stand, the test stand shall be considered a part of the ground plane for testing purposes and shall be bonded accordingly.

B.1.1.3 Power Supply Characteristics

Power supplies for test samples requiring a power source for its operation and not supplied as part of the equipment shall have characteristics and tolerances within the limits of Section 3.2.1.

B.1.1.4 Radio Frequency Absorber Material

Radio Frequency (RF) absorber material may be used in shielded enclosures to reduce reflections from the surfaces of the enclosure to the measurement antennas for non–stirred mode tests only. Any use of RF absorber material shall be documented in the test report.

B.1.1.5 Test Site

B.1.1.5.1 Shielded Enclosures

Shielded enclosures shall be of sufficient size to adequately accept the EUT without sacrificing test accuracy or requiring deviation from the methods specified herein. The characteristics of shielded enclosures shall be defined in the EMI Test Plan.

B.1.1.5.2 Open Field Sites

Open field sites may be used when sufficiently large screen rooms are not available or when the nature of the equipment tested precludes their usage. The ambient requirements of this document shall be observed to the maximum extent possible. Techniques to mitigate the effects of ambient levels that exceed the specified levels of Section 3.2.4.4 shall be detailed in the EMI Test Plan.

B.1.1.5.3 Test Site Atmospheric Conditions

Testing shall be performed under the following atmospheric conditions where possible:

- Temperature: 15 to 35 degrees Celsius
- Pressure: 610 to 780 mm Mercury
- Relative Humidity: 20 to 80 percent of Saturation.

B.1.2 Measuring Equipment

This section describes the test equipment used in the test methods contained in this requirements document.

B.1.2.1 Test Antennas

Antennas used in performing radiated emission and susceptibility tests shall be documented. Receive antenna factors and methods used to establish radiated susceptibility environments shall be detailed in the test procedure and the EMI Test Plan. The following antenna characteristics are recommended:

Frequency	Range	Test Antenna Characteristics
14kHz–30MHz	RE02	Electrically short high impedence electric field probe, vertically polarized. Traditionally the 41” rod with active or passive match-ing to 50 ohms.
14kHz–30MHz	RS03	The parallel plate (and numerous modifications), long wire, and E–field generator are available and listed in order of preference. The E–field generator should be reserved for the case in which the EUT is too large for other methods.
Frequency	**Range**	**Test Antenna Characteristics**

30MHz–200MHz	RE02 RS03	Dipole–like antennas. Typical antenna used in this band has been the MIL–STD–461 biconical. Care should be taken in the antenna selection to ascertain that the balun does an adequate job of match-ing the low frequency high antenna impedance of 50 ohms.
200MHz–1GHz	RE02 RS03	The traditional logconical and the logperiodic are available. The double ridge horn should be avoided, since the gain increases dras-tically with frequency.
1GHz–10GHz	RE03	RE02 Broadband (ridged) or standard gain horns. Logconicals are also available.
10GHz–	RE02 RS03	20–dB standard gain horns.

B.1.2.2 Test Antenna Counterpoise (Monopole)

The following requirements shall be used when rod antennas that require a counterpoise are used. The test antenna counterpoise shall be referenced to the same ground reference used for the (EMI) meter. For measurements in shielded enclosures, the counterpoise shall be bonded to the reference ground plane. The bond strap shall be a solid metal sheet having the same width as the counterpoise, welded along the entire edge at the points of contact. Alternatively, the counterpoise shall be clamped and/or soldered to the ground plane in two places. If desired, the counterpoise may be configured so that one dimension is of adequate length to reach the equipment ground plane. For outdoor measurements, the counterpoise and interference analyzer shall be referenced to a good Earth ground.

B.1.2.3 Use of Measuring Equipment

All laboratory equipment shall be operated as prescribed by the applicable instruction manuals unless otherwise specified herein. This requirements document shall take precedence in the event of conflict with instruction manuals or other documents issued by industry or other government agencies unless identified in an approved EMI Test Plan. For test repeatability, all test parameters used to configure the test shall be recorded in the EMI Test Plan and the EMI Test Report. These parameters shall include measurement bandwidths, video bandwidths, sweep speeds, etc.

B.1.2.3.1 Grounding of Measuring Equipment

To avoid false data that may be introduced by ground loops test equipment shall be referenced to the same ground as the EUT. An equipment safety ground shall be maintained at all times, but for a specific test the ground power line may be broken by means of an isolated transformer or isolation connectors. To avoid high frequency ground loops, test receivers for tests above 30 MHz shall be placed outside the test chamber.

B.1.2.3.2 Equipment Warm–Up Time

Prior to performing tests, the measuring equipment shall be switched on for a period of time adequate to allow parameter stabilization. If the operation manual does not specify a specific warm–up time, the minimum warm–up period shall be one hour.

B.1.2.3.3 Measuring Equipment Calibration

Measuring instruments and accessories used in determining compliance with this requirements document shall be calibrated under an approved program in accordance with MIL–STD–45662A, Calibration Systems Requirements.

B.1.2.3.4 Measurement Accuracy

Test equipment shall be capable of measuring to within the following accuracy:

d. 2% for frequency
e. 3 dB for amplitude.

In the event that an above–specification signal emission is found in any of the specific frequency and amplitude ranges above 100 MHz listed in Section 3.2.4.4, the frequency of the offending signal shall be determined to an accuracy of 0.002%.

B.1.2.3.5 Measurement Bandwidths

The measuring instrument bandwidth shall be less than one third the lowest tuned frequency in the range for narrowband and less than one half the lowest tuned frequency for optional broadband measurements. Optional broadband measurements should be made using bandwidths approximately ten times the narrowband bandwidth.

B.1.2.4 Measurement Antenna Position

B.1.2.4.1 Equipment Under Test Evaluation

The following face probing technique shall be applicable only to large, rack mounted EUTs. EUTs mounted on a ground plane arranged with their interconnecting cables in accordance with the requirements of this document need not be probed. Whenever possible, each EUT shall be mounted so as to have the face with the most connectors facing the measurement antenna. Each face of the EUT shall be probed with a loop or other suitable sensor to determine the localized area producing maximum emission or susceptibility. Probing shall be performed at frequencies known or calculated to represent worst case interference; if no such information is available, probing shall be performed at no fewer points than one frequency for every two octaves over the frequency range of test. The face exhibiting worst case characteristics in any octave or band, provided that band is not less than two octaves, shall face the test antenna for that portion of the frequency scan. Automatic scan techniques may be used to scan all sides.

B.1.2.4.2 Location

When performing radiated emission and susceptibility tests, no points of the antennas shall be less than 30 cm from the floor and ceiling and 1 m from the walls of the shielded enclosure or obstruction.

B.1.2.4.3 Linearly Polarized Antennas

For radiated emission measurements above 30 megahertz (MHz), linearly polarized antennas shall be positioned to measure the vertical and horizontal components of the emission. For radiated susceptibility measurements above 30 MHz, linearly polarized test antennas shall be positioned so as to generate vertical and horizontal fields.

B.1.3 Pulsed Continuous Wave Requirements

The following guidelines govern the requirements for pulsed continuous wave interference:

a. Narrowband limits shall be used
b. Bandwidth correction factors shall not be used.

B.1.4 Arrangement and Operation of Equipment Under Test

B.1.4.1 Control Adjustment

For a representative set of modes of operation, controls on the EUT shall be operated and adjusted as prescribed in the instruction manual or as required by the equipment specification to obtain optimum performance. For susceptibility tests, the most susceptible modes shall be selected. For emission tests, the most noisy modes shall be selected.

B.1.4.2 Signal Inputs

Actual or simulated signal inputs and software required to activate, utilize, or operate a representative set of circuits shall be used during emission and susceptibility testing.

B.1.4.3 Equipment Under Test Arrangement

Interconnecting cable assemblies and supporting structures shall simulate actual installation and usage. Shielded leads used in the test setup shall be the same as specified in approved installation drawings. Diagrams of the cables which interconnect the EUTs shall be documented. Cables and equipment shall not be interposed between the EUT cables and the measurement antennas. When testing within a shielded enclosure, one face of the box comprising the EUT shall be located within 10 cm from the ground plane edge nearest the measurement antenna. All leads and cables shall be located within 10 cm from the ground plane edge nearest the measurement antenna and shall be supported at least 5 cm above the ground plane on non–conductive spacers. Power cable configuration shall simulate actual installation with minimum breakout for use with current probes near feed through capacitors.

B.1.4.4 Bonding and Grounding of Equipment Under Test

Bonding of the EUT for tests shall be in accordance with the approved installation drawings for the equipment. When bonding straps are required to complete the test setup, they shall be the same as those specified in the installation drawings. Portable equipment shall be grounded by the third wire of the power cable. Physical isolation of the portable equipment chassis from structure shall be required for testing. Bonding provisions used for all testing shall be documented in the EMI Test Report.

B.1.4.4.1 Shock and Vibration Isolators

If the EUT is mounted on a base with shock or vibration isolators in the operational installation, the test setup shall include such mounting provisions. Bonding hardware and application for the EUT shall be identical to the approved installation drawing. If no provisions for bond straps are made on the installation drawings, then no bond straps shall be used during testing.

B.1.4.4.2 External Ground Terminal

When an external terminal is provided for a ground connection on the EUT, this terminal shall be connected to the ground plane. The conductor used for the connection shall be of similar dimensions and material to that shown on installation drawings, i.e., length, width, thickness, and diameter.

B.1.4.5 Loads

The EUT shall be loaded with the full mechanical and electrical load or equivalent for which it is designed. If worst case EMI conditions exist at a reduced load, the tests shall include the reduced level loads as well as the full load. This requirement specifically includes electrical loading of the contacts of mechanisms which are designed to control electrical loads even though such loads are physically separate from the EUT. Operation of voltage regulators and other circuits that function intermittently shall be required during testing. The loads used shall simulate the impedance of the actual load. Mechanical devices shall also be operated under load. The EUT shall be actuated by the same means as in the installation. As an example, if a solenoid is actuated by a silicon controlled rectifier, a toggle switch shall not be used to operate the solenoid for the test.

B.1.4.6 Source and Loads for Communications–Electronics Equipment

All RF outputs of communications electronics equipment shall be terminated with shielded dummy loads as appropriate for the EUT and the test being performed, to produce maximum normal output. At the frequencies of concern, the Voltage Standing Wave Ratio of resistive dummy loads, attenuators, directional couplers, samplers, power dividers, and the internal output impedance of standard signal generators shall be no greater than:

a. Transmitter loads; 1.5:1
b. All other dummy loads and pads; 1.3:1
c. Standard signal generators; 1.3:1.

The use of standard signal generators shall be defined in the equipment list of the test procedure.

B.2 Specific Test Procedures and Techniques

B.2.1 Conducted emissions

B.2.1.1 CE01, conducted emissions

Direct current primary power (120V), low frequency, 30 hertz (Hz) to15 kilohertz (kHz).
Direct current secondary power (28V, ±12V, 5V) frequency, 30 Hz to 50 MHz.

B.2.1.1.1 Applicability

The test method for CE01 shall be applicable for measuring narrowband conducted emissions in the frequency range between 30 Hz and 15 kHz on the 120V primary and 30 Hz to 50 MHz on the secondary on the following types of leads:

- dc leads which obtain power from, or provide power to other equipment, distribution panelsor subsystems.

B.2.1.1.2 Test Equipment

The test equipment shall include the following:

f. Current probe
g. Electromagnetic interference analyzer with a narrowband capability
h. 10–microfarad feed–through capacitors.

B.2.1.1.3 Test Setup

The test setup shall be as shown in Figure 41.

B.2.1.1.4 Test Procedure

Measurements shall be taken with the interference analyzer bandwidth as specified in this document.

B.2.1.1.5 Data

Emissions greater than 20 dB below the specified limits shall be logged and reported in the test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded.

B.2.1.2 CE03, Conducted Emissions

Direct current primary power (120V) leads, 15 kHz to 50 megahertz (MHz).
Direct current secondary power (28V, ±12V, 5V) frequency, 30 Hz to 50 MHz.

B.2.1.2.1 Applicability

The test method for CE03 shall be applicable for measuring narrowband conducted emissions in the frequency range between 15 kHz and 50 MHz on the120V primary and 30 Hz to 50 MHz for the secondary on the following types of leads:

c. dc leads which obtain power from other sources or provide power to other equipment, distribution panels or subsystems. Interconnecting leads and cables between equipment that form a subsystem from the same supplier are exempt if the units are tested together.

B.2.1.2.2 Test Equipment

The test equipment shall include the following:

d. Current probe
e. Matching transformer, if required between current probe and the interference meter to allow the measuring system to meet the sensitivity requirements needed to perform the test
f. Interference analyzer
g. Isolation transformer for interference analyzer as required.

B.2.1.2.3 Test Setup

The test setup shall be as shown in Figure 41.

B.2.1.2.4 Test Procedure

Measurements shall be taken with the interference analyzer bandwidth as specified in this document.

B.2.1.2.5 Data

Emissions greater than 20 dB below the specified limits shall be logged and reported in the test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded.

B.2.1.2.6 CE03 Notes

The EUT and EMI instrumentation shall derive their power requirements from separate phases of the ac power source, if possible. The purpose of this requirement is to provide isolation between the EUT and measurement instrumentation through the enclosure power line filters.

CAUTION: The instrumentation shall be properly grounded before applying ac power to prevent potential shock hazard to personnel.

B.2.1.3 CE07, Conducted Emissions

Direct current power leads, spikes, time domain.

B.2.1.3.1 Applicability

The purpose of this test method is to measure in the time domain, the load induced effect on dc power quality caused by cycling the EUT power and operating modes. This method is applicable for measuring time domain spikes occurring when loads are energized in a discrete manner from secondary power (example: remote power controller). Measurement shall be made line–to–line. The requirement for turn–off transients is applicable only when the power switch is contained within the EUT (as opposed to a remotely located power switch or circuit breaker). Investigations using the MSG secondary power only are not required to perform this test.

B.2.1.3.2 Test Equipment

The test equipment shall include the following:

d. Line Impedance Stabilization Network (LISN) as shown in Figure 42
e. Oscilloscope
f. Switch
g. Recording Device
h. Triggering Device

B.2.1.3.3 Test Setup

The setup shall be as shown in Figure 43. The ac measurement shall be made line–to–line, with oscilloscope probes connected between each line to be measured and each of the two channels of the oscilloscope, with the second channel inverted and added to the first channel. The probes shall be attached to the energized line impedance stabilization network, with the switch to the EUT open. The measurement is made when the switch is closed. Prior to making a line to line measurement as described above, it is necessary to match the gain of the two oscilloscope channels within some tolerance. The tolerance required is what is necessary to reduce common mode “residues” to a level that will not affect test results.

B.2.1.3.4 Test Procedure

With the test setup of Figure 43, cycle the power to the EUT on/off and exercise all the appropriate internal EUT mode switches. Record the voltage transients. Compare against the appropriate transient specification.

B.2.1.3.5 CE07 Notes

A LISN shall be inserted in each pair of lines tested. See Figure 42. The series resistance shall be based on the final installation dc resistance of the Space Station Power Distribution System (PDS) between the DC–to–DC Converter Unit (DDCU) and the start of the dedicated feeders to the installed EUT. The oscilloscope shall provide a minimum single event bandwidth of 20 MHz, effective resolution of 8 bits (for a digital oscilloscope). The oscilloscope shall have a two channel capability, with the ADD and INVERT modes available, again with a 20–MHz single event bandwidth. If the EUT is cycled on/off by a controlled remote switch or breaker, then this function shall be provided for in the test setup. A mercury (Hg) relay switch or equivalent which is not a source of significant transient effects shall be used. The triggering device is critical to a successful test. Triggering shall be provided such that, as a minimum, 90% of the leading edge of the transient waveform can be viewed.

B.2.2 Conducted Susceptibility

B.2.2.1 CS01, conducted susceptibility

Direct current power leads, 30 Hz to 50 kHz.

B.2.2.1.1 Applicability

The test method for CS01 shall be applicable for determining susceptibility of equipment and subsystems to electrical energy appearing on dc power leads.

B.2.2.1.2 Test Equipment

The equipment shall consist of the following:

c. Signal generator capable of providing the required test frequencies
d. Audio power amplifier of 50 watts (W) or greater with output impedance less than or equal to 2.0 ohms and capable of delivering 50 W into a 0.5–ohm resistive load connected across the isolation transformer secondary
e. Oscilloscope, voltmeter
f. Isolation transformer
g. A 100–microfarad capacitor may be required as a shunt to dc power source impedance if
h. difficulty is encountered in obtaining the required test voltage.

B.2.2.1.3 Test Setup

The test setup shall be as shown in Figure 44. Appropriate monitoring devices shall be connected to EUT outputs.

Caution: Since the transformer secondary winding may provide substantial inductance, the test setup and EUT should be evaluated for potential damage from back-EMF should the power supply output suddenly open or short. A snubber circuit, clamping diodes, the suggested power supply bypass capacitor, or other methods may be used to protect the EUT, power supply, transformer, and test equipment from over-stress from a back-EMF pulse. This protect should especially be considered for testing of Protoflight and Flight hardware.

B.2.2.1.4 Test Procedure

The signal generator shall be tuned through the required frequency range with the power amplifier output adjusted to the level specified in Section 3.2.4.4. The equipment shall be monitored for:
f. Malfunction
g. Degradation of performance

h. Deviation of parameters beyond tolerances indicated in the equipment specification.

B.2.2.1.4.1 Susceptibility

When an EUT susceptibility is noted, the output level shall be decreased to determine the susceptibility threshold level. This value shall be recorded. The requirement is also met when the audio power source, adjusted to dissipate 50 W in a 0.5–ohm load, can not develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

B.2.2.1.4.2 Supply Voltage

The required nominal supply voltage applied to the EUT shall be measured and maintained within specified tolerances during the test.

B.2.2.2 CS02, Conducted Susceptibility

Direct current power leads, 50 kHz to 50 MHz.

B.2.2.2.1 Applicability

The test method for CS02 shall be applicable for determining susceptibility of equipment and subsystems to electrical energy appearing on dc power leads including power returns and which are not grounded internally to the equipment or subsystem.

B.2.2.2.2 Test Equipment

The test equipment shall consist of the following:

f. Signal Source: a 50–ohm output impedance source capable of generating 1 volt (V) rms. and/or 1 W output, minimum, into a 50–ohm load
g. LISN as specified in Figure 42, Note: Lead not being tested should bypass LISN.
h. Voltmeter, oscilloscope, or interference analyzer
i. Coupling capacitor: The capacitor shall be used to isolate the power line frequencies from the signal source and shall have an RF impedance of 5 ohms or less, over the frequency range of the test. The capacitor may be changed during the test to maintain the impedance.

B.2.2.2.3 Test Setup

The general test setup shall be as shown in Figure 45.

B.2.2.2.4 Test Procedure

- The coupling capacitor and voltmeter, oscilloscope, or interference analyzer shall be connected within 5 cm of the termination to the EUT
- The test signal shall be applied to each power lead

- When testing equipment using single point grounds (dc power input leads isolated within the EUT), the test signal shall be applied between each power lead or ground return lead and the ground plane
- The voltage across the injection terminal to ground of the EUT shall be measured and recorded
- If the EUT is susceptible to the applicable limit level, then the signal source output shall be decreased to determine and record the threshold of susceptibility.

B.2.2.3 CS06, Conducted Susceptibility

Spikes, power leads.

B.2.2.3.1 Purpose

The test method for CS06 shall be used to determine equipment susceptibility to spike interference on power leads, including grounds and returns which are not grounded internally to the equipment or subsystem.

B.2.2.3.2 Applicability

CS06 shall be applicable to equipment and subsystem power leads, including grounds which are not grounded internally to the equipment or subsystem.

B.2.2.3.3 TEST EQUIPMENT

The test equipment shall consist of the following:

- Spike Generator
- Capacitor as required
- Oscilloscope.

B.2.2.3.4 Test Setup

The test setup shall be as shown in Figure 46 or Figure 47.

Caution: Since the transformer secondary winding may provide substantial inductance, the test setup and EUT should be evaluated for potential damage from back-EMF should the power supply output suddenly open or short. A snubber circuit, clamping diodes, the suggested power supply bypass capacitor, or other methods may be used to protect the EUT, power supply, transformer, and test equipment from over-stress from a back-EMF pulse. This protect should especially be considered for testing of Protoflight and Flight hardware.

B.2.2.3.5 Test Procedure

Test procedures for testing equipment with dc leads shall be as follows:

f. The EUT and test instrumentation shall be connected as shown in Figure 46 or Figure 47.

g. Either a series or shunt test method may be used.
h. The applied spike amplitude, rise time, and duration, as measured by the oscilloscope across the input terminals of the EUT, shall follow the typical wave shape and amplitude as specified in Section 3.2.4.4. The applied spike shall be developed across a non–inductive 5–ohm resistor and then applied to the EUT.
i. Repetitive (6 to 10 pulses per second) spikes, both positive and negative, shall be applied to the EUT ungrounded input lines for a period not less than 2 minutes in duration. On equipment employing gated circuitry, the spike shall be triggered to occur within the time frame of the gate.
j. If susceptibility occurs, then its threshold level, repetition rate, and time of occurrence on circuit gates shall be determined and recorded.

B.2.2.3.6 CS06 Notes

The spike generator shall have the following characteristics:

– Pulse width of 10 and 0.15 microsecond
– Pulse repetition rate of 3 to 10 pulses per second
– Voltage output as required by Section 3.2.4.4
– Output control
– Adequate transformer current capacity commensurate with line being tested
– External synchronization capability
– External trigger capability
– Capacitor may be used to protect dc power source. Any oscilloscope with 10–MHz
– bandwidth or greater and sweep rates greater than 10 times the pulse rate shall be acceptable.
– Output impedance 2 ohms or less for 0.15–microsecond transient and 1 ohm for
– 10–microsecond transient.

B.2.3 Radiated Emissions

B.2.3.1 RE02, radiated emission

Electric field, 14 kHz to 20 GHz.

B.2.3.1.1 Applicability

The test method for RE02 shall be applicable for the measurement of radiated emissions from all equipment and subsystems, cables (including control, pulse, IF, power and antenna transmission lines), and interconnecting wiring of the equipment and subsystem; for narrowband emissions, it applies at the fundamental frequencies and all spurious emissions including harmonics, but does not apply for radiation from antennas.

B.2.3.1.2 Test Frequency Range

The test frequency range shall be 14 kHz to 20 GHz.

B.2.3.1.3 Test Equipment

The test equipment shall be as follows:

- Test antennas
- Interference analyzer (set in peak node).

B.2.3.1.4 Test Setup

The basic test setups shall be as shown in Figures 48 and 49. EUT antenna terminals, if any, shall be connected to shielded dummy loads.

B.2.3.1.4.1 Non–Portable Equipment

Non–portable equipment is permanently connected either physically or electrically to a vehicle, system, or installation. It shall be tested in accordance with the setup shown in Figure 48.

B.2.3.1.4.2 Portable Equipment

Portable equipment, including manpack operable equipment and test equipment, shall be tested in accordance with the setup shown in Figure 49.

B.2.3.1.4.3 Equipment Classified Both Portable and Non–Portable

Equipment falling into both the non–portable and portable categories shall be tested both ways.

B.2.3.1.5 Test Procedure

B.2.3.1.5.1 Locate Maximum Radiation

The EUT shall be probed as indicated in paragraph B.1.2.4.1 to locate the points of maximumradiation from the EUT.

B.2.3.1.5.2 Antennas

The test antennas shall be selected and positioned as stated in paragraph B.1.2.4 at a test distance of 1 m. In the frequency range of 30 MHz to 20 GHz, linearly polarized antennas shall be positioned so as to make both vertical and horizontal measurements. If a rod antenna with a counterpoise is used, then the counterpoise of a 41–inch rod antenna shall be bonded in accordance with the requirements of this document.

B.2.3.1.5.3 RE02 Notes

RE02 shall be measured in peak detector mode.

B.2.4 Radiated Susceptibility

B.2.4.1 RS02, Radiated Susceptibility

Magnetic induction field.

B.2.4.1.1 Applicability

The test method for RS02 shall be applicable for the determination of the susceptibility of cable connected equipment to short duration, fast risetime induction fields electromagnetically coupled into the equipment through the wiring connecting equipment.

B.2.4.1.2 Test Equipment

The test equipment shall consist of the following:

— Spike generators as specified in Method CS06 of this document
— A dual channel oscilloscope having a 10–MHz bandwidth.

B.2.4.1.3 Test Setup

The test setup shall be as indicated in Figure 50. The cable under test (CUT) shall be stressed by taping an insulated AWG#12 (or larger) size wire (coupling wire) to each CUT in the test setup, parallel to the CUT, running the entire length of the bundle to 15 cm from each end connector. The portions of the test wire not taped to the CUT shall be well removed from the CUT in order to couple the maximum flux into the CUT. In some cases where it is known that the Space Station installed cable will be significantly longer than the CUT, it may be desired to simulate stressing of the installed length by multiple parallel wraps of the test wire such that the meter turns product of the test wire taped to the CUT is numerically equal to the length (in meters) of the installed cable. In such cases, it is important that the portions of the test wire not adjacent to the CUT be not only removed from the vicinity of the CUT, but also that each layer of the wrap be removed from adjacent layers to limit inductance which can cause an inability to provide sufficient current to perform the test. For the same reason, it is important to have a controlled test wire configuration so that the calibrated current is unchanged for the duration of the test.

B.2.4.1.4 Test Procedure

B.2.4.1.4.1 Spikes

Two spike signals, both positive and negative, shall be impressed at a rate of 400 Hz or at the maximum rate at which the waveforms and amplitudes specified in Section 3.2.4.4 can be achieved. The waveforms and amplitudes of the spike signals shall be measured across a non–inductive 10–ohm resistor. The measurement device shall be an oscilloscope, configured to read differentially across the resistor. That is, two probes shall be used to connect at the resistor terminals, and one channel’s input shall be subtracted from the other (oscilloscope in ADD and INVERT modes).

B.2.4.1.4.2 Equipment Under Test Performance

The EUT shall be monitored for susceptibility. The monitoring period shall be sufficient to check all modes of the EUT for susceptibility. The susceptibility criteria as well as the appropriate monitoring period shall be defined in the approved test plan. Thresholds of susceptibility shall be determined and recorded where susceptibility is noted. Because the interference signals coupled into the CUT are functions of both currents in the test wire and the separation of the test wire from the CUT, the threshold of susceptibility shall be specified two ways. First, the spike amplitude shall be diminished until the threshold is reached. That spike amplitude shall be recorded. Secondly, the amplitude and waveform specified in Section 3.2.4.4 shall be re–established, and the test wire shall be removed a small distance from the CUT. The test shall be rerun to determine the threshold of susceptibility for the separation of test wire and CUT. If the CUT is comprised of many bundle classes, the most sensitive bundle class in the CUT shall be used to determine the separation.

B.2.4.1.5 RS02 Notes

Power input and output leads are exempt from this test. It is not intended that individual wires be tested but rather that wire bundles configured per Space Station installation drawings be tested. CUTs which have a diameter greater than 1 cm shall have the test wire sequentially placed at different locations around the periphery of the CUT in order to assure that all wires are adequately stressed. Alternately, to more quickly complete the test, an extra wire may be laid up parallel to the CUT, on the opposite side of the CUT from the first wire, for CUTs of greater than 1–cm diameter. Each such extra wire shall have currents driven into it at separate times. Current carrying wires shall be kept 15 cm away from cable connectors. All cables shall be at least 5 cm above the ground.

B.2.4.2 RS03, Radiated Susceptibility

Electric Field, 14 kHz to 20 GHz.

B.2.4.2.1 Applicability

The test method for RS03 shall be used to determine equipment and subsystem susceptibility in the presence of an electric field.

B.2.4.2.2 Test Equipment

The test equipment shall consist of the following:

- A signal source capable of generating electric fields and frequencies specified in Section 3.2.4.4
- An interference analyzer to measure test field strengths
- Antennas as specified in paragraph B.1.2.1
- An output monitor to monitor performance of the EUT.

B.2.4.2.3 Test Setup and Procedures

B.2.4.2.3.1 Placement of Antennas

The test setup shall be as required by the general testing requirements of this document for placement of antennas.

B.2.4.2.3.2 Test Signals

Test signals shall consist of two categories. These categories are based on standard test frequencies and frequencies at amplitudes that are defined by the Space Station design.

B.2.4.2.3.3 Test Signal Levels

The test signal levels shall be as specified in Section 3.2.4.4. The test signal shall be established at the mounting location of the EUT. The field strengths shall be verified as required. Standard test frequencies shall consist of a frequency sweep from 14 kHz to 200 MHz at 5 V/m, 200 MHz to 8 GHz at 60 V/m and 8GHz to 10 GHz at 20 V/m. The Station defined frequencies are 2.2 GHz at 161 V/m, 8.5 GHz at 79 V/m and 14.8 – 15.2 GHz at 250 V/m.

B.2.4.2.3.4 Signal Modulation

Signal modulation for Station derived frequencies shall be defined by the tier 1 contractor and both the type of modulation and percentage of modulation, if applicable, shall be documented. The tier 1 contractor shall also define the signal modulation characteristics for the standard test frequencies. The minimum criteria for the signal modulation of the standard test frequencies shall be as defined in this document.

B.2.4.2.3.5 Antenna Selection

Fields shall be generated, as required, with signal sources and antenna that provide the required field strength. Longwire antennas or parallel strip line antennas may be used if they are applicable and desired.

B.2.4.2.3.6 Field Strength Calibration

The specified field strength shall be established prior to the actual testing by placing a field measuring antenna at the same distance and in the same relative location as the EUT and by adjusting the signal level applied to the transmitting antenna until the required field intensity is indicated. The voltage or power at the input terminals of the transmitting antenna required to establish the specified field shall be monitored and recorded. When performing this calibration in a shielded enclosure, the measurement antenna shall be placed in either the exact location that the EUT will occupy or shall be in a position which simulates exactly the geometry of the EUT location with respect to distances to reflective surfaces. This calibration may be used for all subsequent testing provided that either the data were taken in a reflective free area or the same shielded enclosure EUT location was used.

B.2.4.2.3.7 Large Equipment Under Test

When a large EUT will be immersed in a field, the transmitting antenna shall be placed at a distance sufficient to allow the entire EUT to fall within the 3–dB beamwidth of the transmitted field. If this is not feasible because of either difficulty in generating the required field at the greater distance or the nature of the antenna radiation characteristics, then the EUT may be tested in segments where each segment is equal in dimension to the 6–dB beamwidth of the antenna radiation characteristic. For a whip transmitting antenna, the horizontal segments shall have length no greater than those given by the following equation: $L = 2\,[R\,d - (d/2)^2\,]^{1/2}$, where R is the test distance and d is the EUT width measured along a line forming a right angle with the face of the EUT which is directed toward the transmitting antenna.

B.2.4.2.3.8 Susceptibility Determination

The signal generators shall be tuned through the required frequency ranges with the power output adjusted to provide the fields specified in Section 3.2.4.4. The equipment shall be monitored for evidences of susceptibility:

- Malfunction
- Degradation of performance
- Deviation of parameters beyond tolerances indicated in the EUT specification at frequencies where susceptibility is encountered, the threshold of susceptibility shall be determined. All pertinent data shall be recorded.

B.2.4.2.3.9 Minimum Criteria for Signal Modulation

Test signals shall be modulated according to the following minimum criteria for testing performed using the standard test frequencies.

B.2.4.2.3.9.1 Equipment Under Test With Audio Channels/Receivers

f. Amplitude modulation (AM) Receivers: Modulate 50 percent with 1000–Hz sinewave.
g. Frequency modulation (FM) Receivers: When monitoring signal to noise ratio, modulate with 1000–Hz sinewave using 10–kHz deviation. When monitoring receiver quieting, use no modulation.
h. Single Side Band Receivers: Use no modulation.
i. Other Equipment: Same as for AM receivers.

B.2.4.2.3.9.2 Equipment Under Test With Video Channels Other Than Receivers

Modulate 90 to 100 percenT with pulse of duration 2 per bandwidth and repetition rate equal to bandwidth/1000 where bandwidth is the video bandwidth.

B.2.4.2.3.9.3 Digital Equipment

Use pulse modulation with pulse duration and repetition rates equal to that used in the equipment.

B.2.4.2.3.9.4 Non–Tuned Equipment

Amplitude modulate 50 percent with 1000–Hz sinewave.

B.2.5 Leakage Emissions

B.2.5.1 LE01, Leakage Emissions, Power User Leakage Current

B.2.5.1.1 Applicability

The test method for LE01 shall only be applicable to equipment and subsystems that use ac power.

B.2.5.1.2 Test Equipment

The test equipment shall be as follows:

3 ac power source

4 A current meter capable of measuring 10 percent, minimum, of the test limit current at the frequency of the power source

5 An insulator/isolator of dimensions sufficient to limit the capacitance between the chassis and the ground plane to 10 picofarads maximum and the resistance between the chassis and the ground plane to 10^6 ohms dc, minimum.

B.2.5.1.3 Test setup

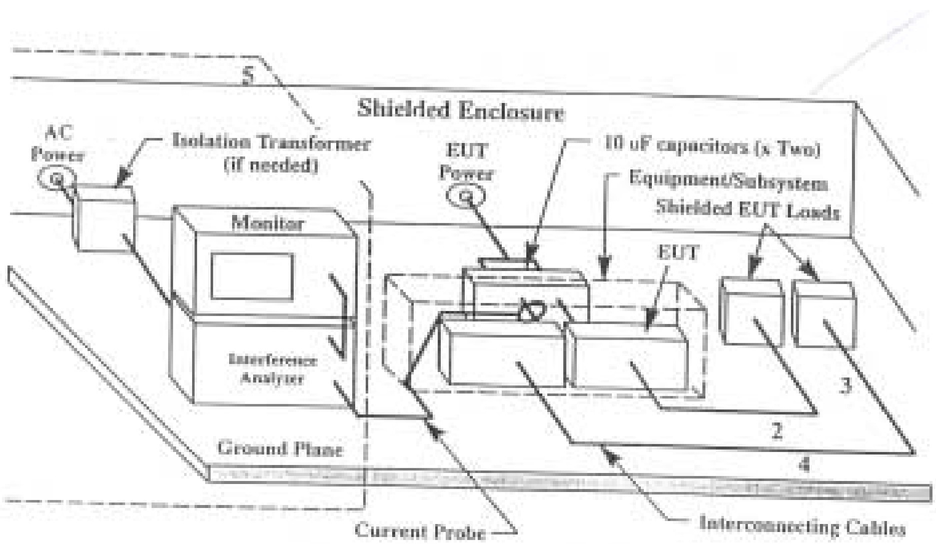
The test setup shall be as shown in Figure 51 or equivalent.

B.2.5.1.4 Test Procedure

The EUT shall be electrically energized and operated as specified in its operating manual. While the EUT is operating, the leakage current at the power frequency shall be measured and recorded. The EUT shall be tested for each mode of operation.

B.2.5.1.5 Leakage Current Limit

The power frequency leakage current shall not exceed the value specified in Section 3.2.4.4.

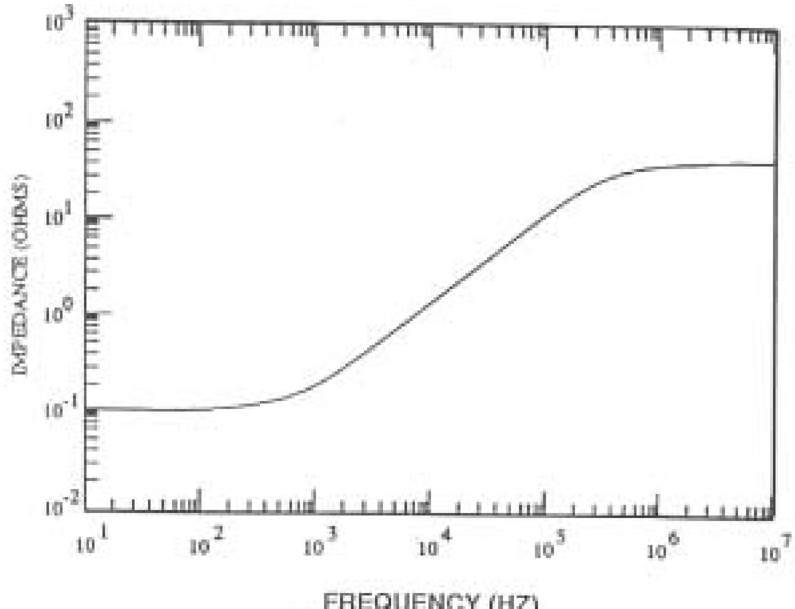


Notes:

1. Shielded enclosure is bonded to ground plane every 90 cm or less.
2. Cable bundles are separated by at least 5 cm.
3. Cables are placed at least 5 cm above ground plane.
4. Cables and leads are placed within 10 cm of edge of ground plane.
5. May be located in a different room.

Figure 41. <u>Typical Test Setup for Measuring Conducted Emissions on DC Power Lines or Interconnecting Leads (CE01 and CE03)</u>

L	=	10 µH
R_p	=	25 ohms
R_s	=	0.05 ohms
C	=	5000 µF for energy storage. May be more or less, purpose is to provide stiff voltage at LISN input.



LISN Impedance vs Frequency

Schematic:

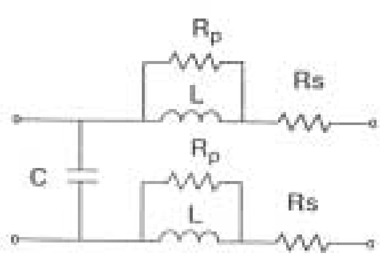
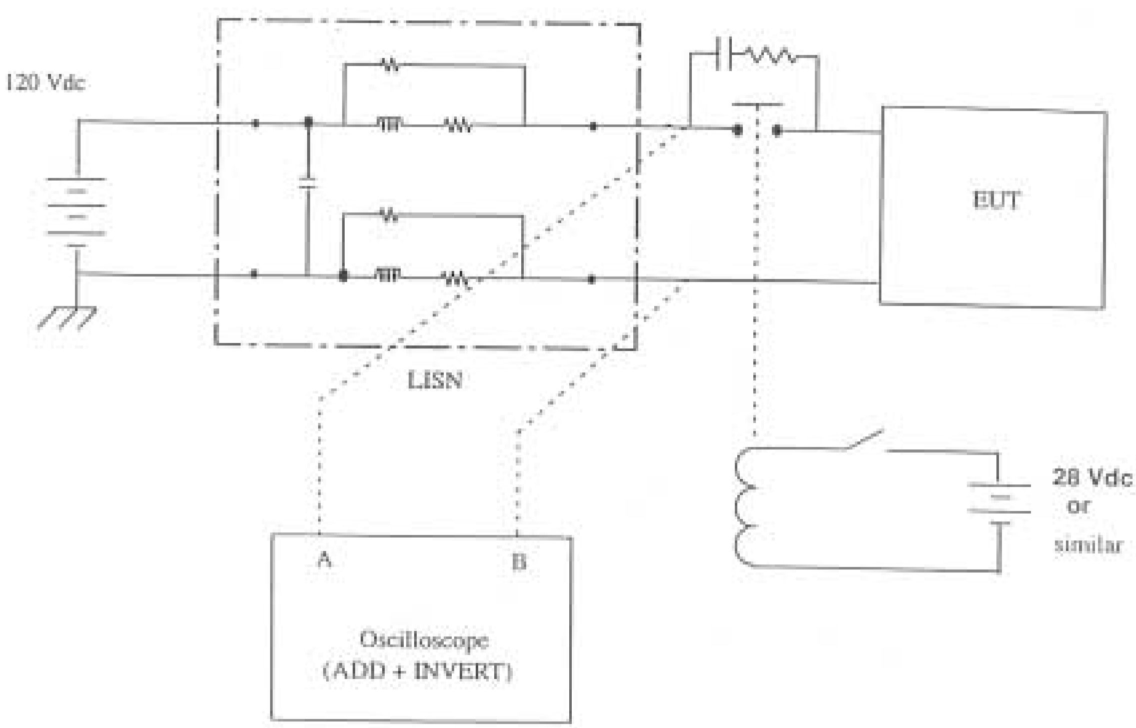


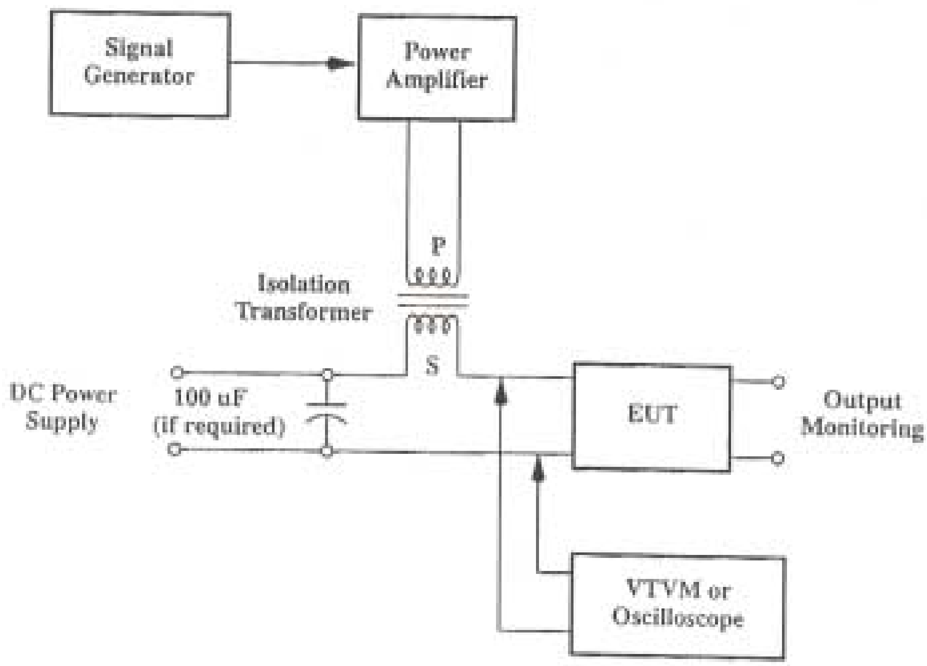
Figure 42. **<u>LISN for CE07 Measurement</u>**



NOTE: Hg switch or relay should be filtered to reduce effects of arcing. Capacitor reduces arcing on turn–off, resistor reduces effect on turn–on (due to capacitor).

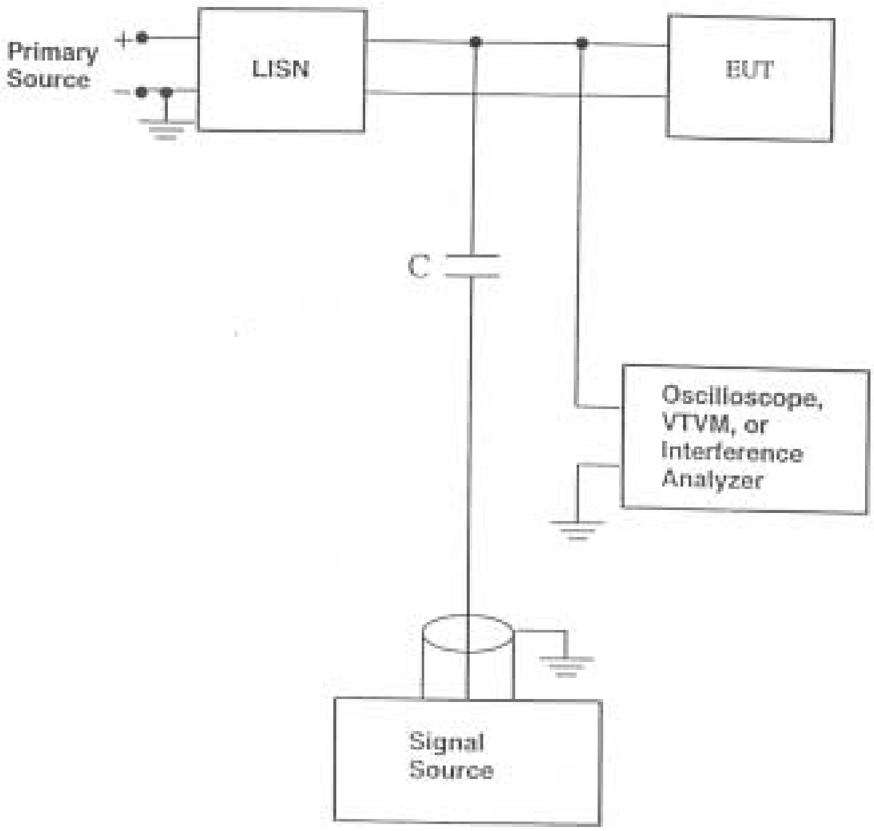
Note: Change parallel resistor in LISN to be in parallel with inductor only.
Swap words “add” and “invert”.
Put capacitors in the oscilloscope lines.

Figure 43. <u>CE07 Test Setup</u>



Note: Put capacitors in the oscilloscope lines as necessary to prevent over-stressing oscilloscope.

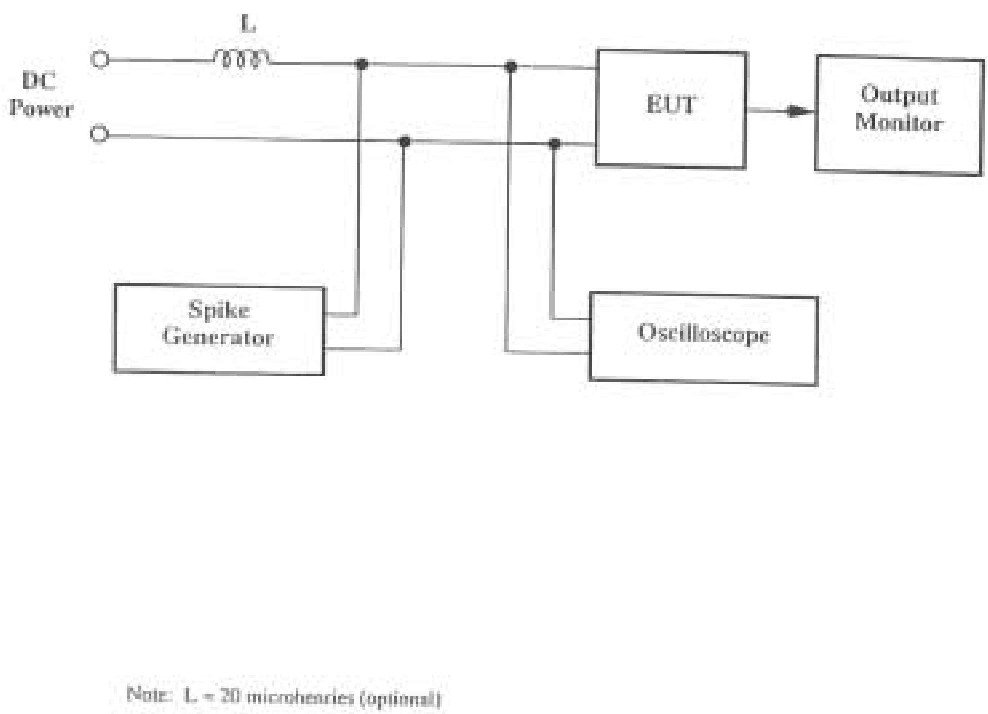
Figure 44. **<u>Conducted Susceptibility, 30 Hz to 50 kHz Typical Test Setup (CS01)</u>**



1. The value of C shall be chosen such that Xc<5 ohms over the test frequencies
2. Connect the coupling capacitor and the VTVM, Oscilloscope, or Interference Analyzer, within 5 cm of the termination to the EUT

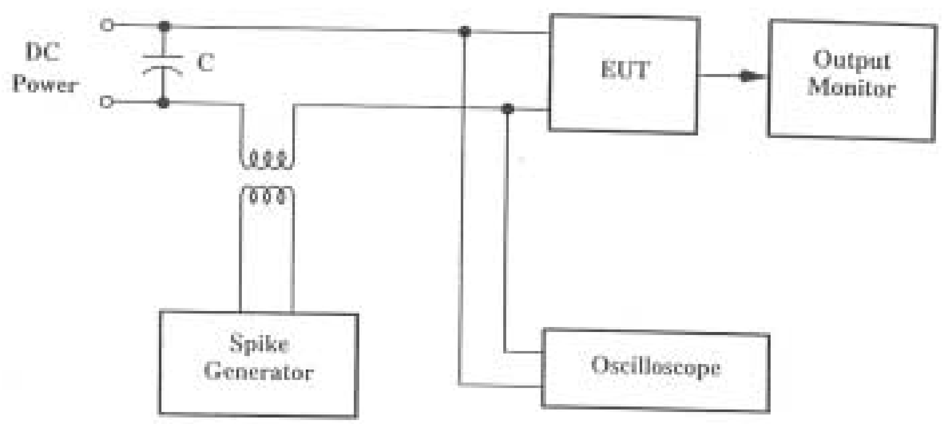
Note: Power lead not being tested should bypass LISN

Figure 45. <u>Conducted Susceptibility, 50 kHz to 50 MHzTypical Test Setup (CS02)</u>



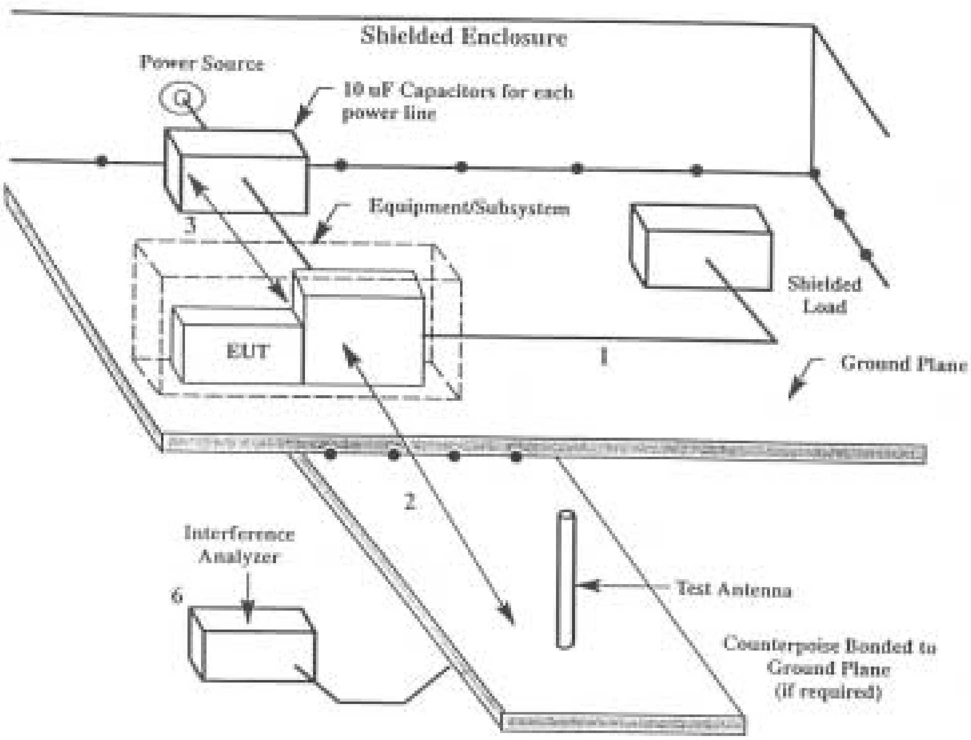
Note: Put capacitors in the oscilloscope lines as necessary to prevent over-stressing oscilloscope.

Figure 46. **<u>Conducted Susceptibility, Spike Parallel Injection Test Setup (CS06)</u>**



Note: Capacitor may be used to protect the DC power supply.

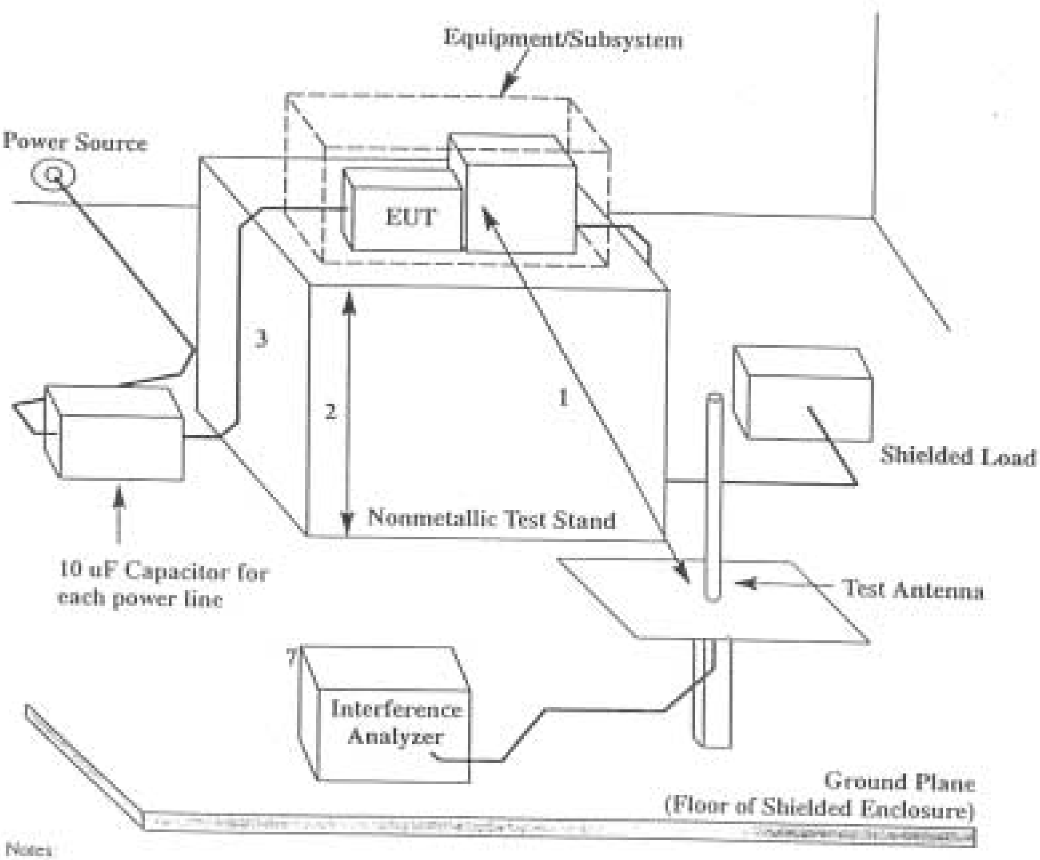
Figure 47. <u>Conducted Susceptibility, Spike Series Injection Test Setup (CS06)</u>



Notes:

1. Cables are placed at least 5 cm above ground plane.
2. Requirement at 1 meter.
3. Input power leads are greater than two meters and less than three meters in length.
4. If the test sample is comprised of more than one unit, interconnecting cable lengths of at least 2 meters shall be exposed to the test antenna except for deliverable cables whose length is less than 2 meters.
5. Matching network is mounted below counterpoise.
6. For measurements above 30 MHz, the interference analyzer shall be placed outside the shielded enclosure.

Figure 48. <u>Typical Test Setup for Radiated Measurement (RE02)</u>



Notes:

1. Required at 1 meter.
2. Typically 1 meter.
3. Power leads are greater than 2 meters and less than 3 meters in length.
4. Height of test antenna shall be located for maximum pickup.
5. Only the test sample and the Interference Analyzer shall be connected to the enclosure power.
6. Matching network is mounted below the counterpoise.
7. For measurements above 30 MHz, the interference analyzer shall be placed outside the shielded enclosure.

Figure 49. <u>Typical Test Setup for Radiated Measurements on Portable Equipment (RE02)</u>

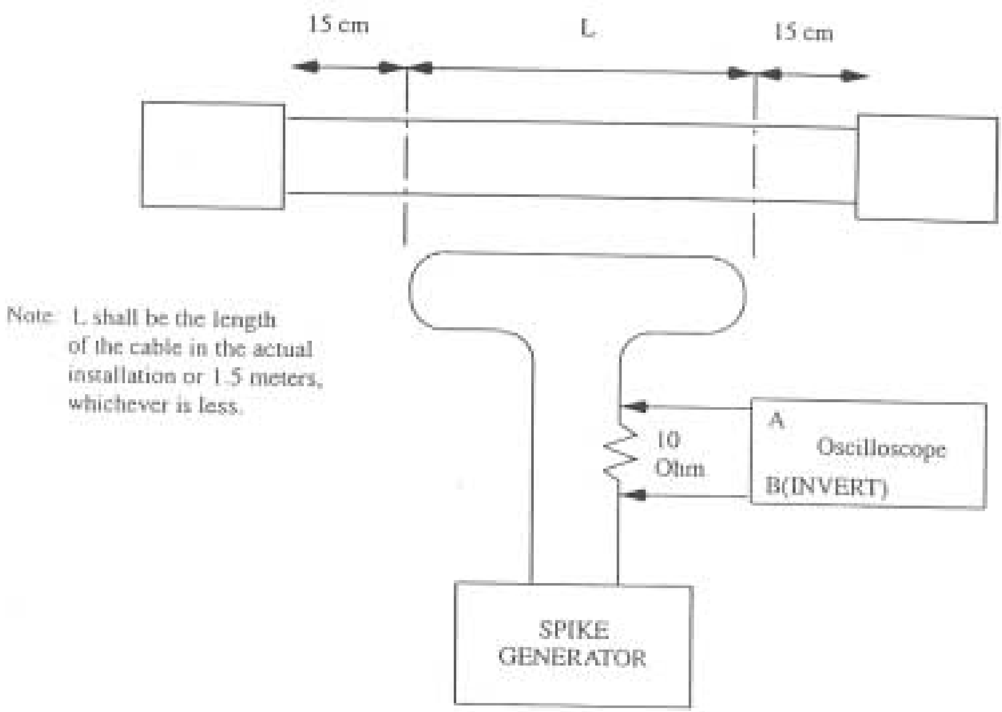


Figure 50. <u>RS02 Cable Test Setup</u>

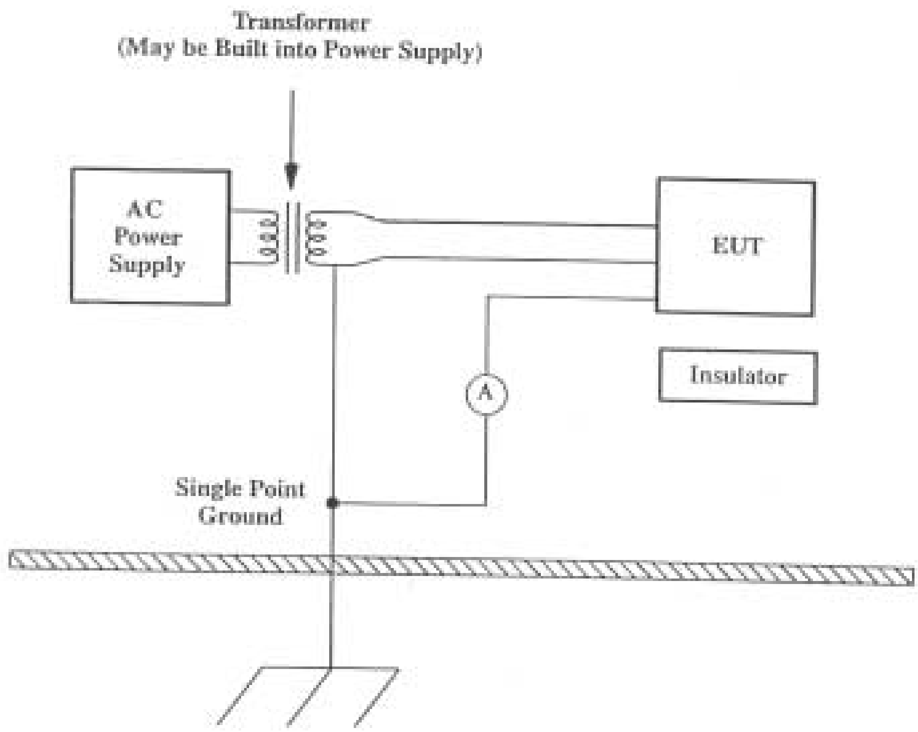


Figure 51. Typical Test Setup, Power User Leakage Current (LE01)

APPENDIX C
INSTRUCTIONS FOR LABELS AND DECALS

C.1 Introduction

Appendix C provides the instructions for the approval of payload labels. The development of labels will be a joint process requiring the cooperative efforts of ISS Payload Label Approval Team (IPLAT), MSG Investigation Integration Team and the MSG Investigator. The process for developing labels, from the beginning to the delivery of flight certified labels which have been approved by the IPLAT, is documented in Figure 52. To understand the priorities of the instructions, the following definitions need to be applied throughout Appendix C. Statements with "must" will be used for instructions which are required to be met for the IPLAT to provide approval. Statements with "should" will be used for instructions which are incorporated into the label unless adequate justification is provided to IPLAT to warrant exempting the label instruction.

C.2 Responsibilities

The Investigator shall provide label drawings, label location drawings and information sufficient to enable IPLAT to determine the instructions herein are met. The Investigator shall coordinate with the MSG Integration Team before submitting the label drawings for approval. IPLAT is responsible for reviewing all payloads labels, providing guidance to the PD and granting approval based on the instructions herein. IPLAT is also responsible for performing a human engineering assessment of the labels and ensuring the labels are appropriate from a human engineering perspective including commonality, standardization, and operations nomenclature. Upon receiving Form 733b, IPLAT has 10 working days for either assessing, approving, and verifying the labels or for providing redlines to the label drawings. The PTR is responsible for resolving issues and disagreements between the PD and IPLAT.

C.3 IPLAT Approval Instructions

IPLAT will use the following instructions in reviewing and providing the approval of payload labels.

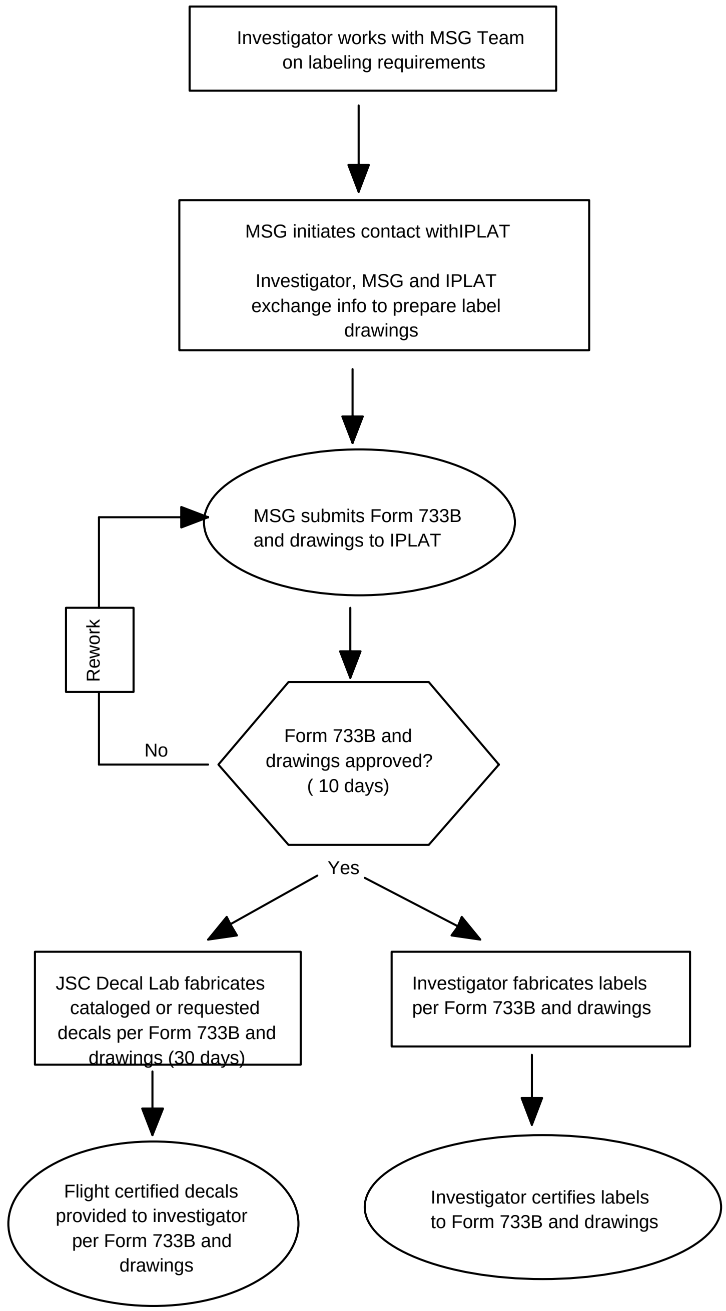


FIGURE 52. Label Process

C.3.1 Ground Assembly and Handling

Product marking for ground assembly and handling should be in accordance with MIL–STD–130, section 4, except paragraph 4.1.c.

C.3.2 Function Considerations

a. Decals and placards should contain information required by the user regarding the purpose, the function, and/or the functional result of the use of equipment items. Engineering characteristics or nomenclature may be described as a secondary consideration.

b. Instrument decals and placards, for example, should be labeled in terms of what is being measured or controlled. Calibration data may be included where applicable.

C.3.3 Payload Orientation

A. Payload labeling, displays, and controls must have a consistent rack vertical orientation arrangement with the rack vertical axis origin at the bottom of the rack hinge point.

B. Payload labels required for operations with the rack(s) rotated should be oriented with respect to required crew positions.

C.3.4 Container Content Identification

Deleted (moved to C.3.5.4.1)

C.3.5 Labeling Design

C.3.5.1 Labeling Standardization

a. Standard decals needed by the PD which are available in JSC 27260, Decal Process Document and Catalog must be obtained from the Decal Design & Production Facility (DDPF) or designed to be identical to them. Examples of labels found in the catalog are: IMS, PFE, toxicology, hazardous, cautions and warning, rack power switch, fire indicators, etc. The DDPF is also available to the PDs for fabricating labels not found in JSC 27260.

b. Labeling must be standardized between and within systems.

c. Operations Nomenclatue (Op Nom)

   (1) Non-IMS Hardware Labels - Nomenclature on all non IMS hardware labels must conform to the operational nomenclature guidelines for content (characters used) provided in SSP 50254, Operations Nomenclature. The format for these labels is upper case, as required in paragraph E below.
   (2) IMS Labels – When nomenclature is used above the bar code of an IMS label:

a) Such nomenclature must conform to SSP 50254 guidelines for both content and format (mixed case).
b) Such nomenclature must match the nomenclature on the hardware label, except that IMS label text is in mixed case, and hardware label text is I upper case.

e. Label Text

(1) Upper Case – Labels for equipment, displays, controls, switch positions, connectors, cables/hoses, LEDs, stowage containers, etc., must be listed in upper case letters only. This includes abbreviations and acronums.

(2) Payload Name labels

a) Spelling Out vs. Acronyms – The name label for the "main unit" of the payload must spell out the name, followed by the acronym in parentheses, even if the acronym is an approved Op Nom. The Op Nom acronyms may then be used on all subordinate equipment. For example: The rack for SRF should spell out " SCIENCE RESEARCH FACILITY (SRF)". All subordinate equipment may then use the SRF acronym, like "SRF ANALYZER MODULE".
b) Font size for name labels-The font size for the name label of an item should not be less than 12 point.

(3) Title nomenclature must be consistent with procedural handbooks and checklists.

C.3.5.2 Readability

A. Decals and placards should be as concise and direct as possible.

B. Abbreviations

1) Deleted
2) Periods should be omitted except when needed to preclude misinterpretation.

C. Decal and Placard Life

1) Payloads must provide labels that are readable for the lifetime of the payload's operations, which are replaceable.

D. Language

1) Decals and placards must be written in the English language.
2) If dual languages are used, English must be used first and with lettering at least 25% larger than the secondary language.

E. Decals and placards should be designed so as to minimize visual clutter.

F. Illumination – Labels and markings should be designed to be read at all general illumination levels and color characteristics.

G. Displays and Controls Title Selection

Physical Hardware – When verbs are used to label physical hardware (buttons, switches, controls, etc.), the present tense should be used. For example: OPEN or CLOSE, BEGIN, or END, START or STOP, etc.

Physical Hardware Linked to Software Displays – If physical hardware is linked to and/or represented by software displayed data or controls (i.e. LCD), the labels for the physical hardware and the software representation must use the same terminology.

C.3.5.3 Label Placement

a. All labels must be placed on the payload hardware in accordance to the label location drawings. See Figure 53 for miscellaneous label placement example.

(1) The IMS label should be placed in the upper left corner of the dominant face of the payload.

(2) Payload Name Label

a) The payload name label should be placed to the right of the IMS label.

b) The payload name label must spell out the name of the payload if it is considered the “main unit”. The acronym, if applicable, should follow in parentheses. The acronym may then be used on all subordinate equipment.

c) The font size of the payload name label should be the largest one for the entire payload.

b. Loose Equipment –

(1) The IMS label should be laced in the upper left corner (if there is one) of the dominant face of the item. If there is no upper left corner, place the IMS label either to the extreme left (see example L of Figure 54), or at the top of the dominant face.

(2) Name Label

a) If the dominant face of the item is populated with controls, the name label should be placed immediately to the right, or below the IMS label. If the dominant face is blank (such as a binder or stowage bag, as in example B of Figure 54, then the name label should be placed in the center of the face.

b) Small Items – In the case of very small equipment items, an IMS label with the equipment’s name in the text portion above the bar code is sufficient to satisfy both the IMS and Name label requirements.

c) Control Panels

1) Positions- Labels must be centered above connectors, switches, LEDs, displays, controls, etc. Labels may be placed in other locations when they cannot dimensionally fit in the required location, or if they would be obstructed by items lide cables and hoses, or to preclude misassociation with adjacent items.

2) Size – Labels for controls on a panel should be smaller than the name label for the panel, and should be between 10 and 20 point font. Different levels of controls should be graduated in size. For example, grouping label titles should be larger than the labels for the controls within them. Similar levels of controls should be the same size. See Figure 53 for examples.

d. Part Number and Serial Number Labels – Part Number and Serial Number labels should be placed together for ease of identification. The Part Number label should be arranged to the left or above the Serial Number label. P/N and S/N, which are the standard Op Nom representations of Part Number and Serial Number, respectively, should be used.

e. Orientation – All markings and labels must be oriented with respect to the local worksite plane so that they read from left to right. Vertical orientation, with letters arr4anded vertically if the text is short (e.g. DATA J3), or rotating the label 90 degrees when the text is long (e.g. PAYLOAD ELECTRONICS MODULE), is permissible when the marking or label does not fit in the required orientation.

f. Visibility – Labels must be placed on equipment so that they are visible when the equipment is used or accessed. Markings should be located such that they are perpendicular to the operator’s normal line of sight whenever feasible and should not be less than 45 degrees from the line of sight.

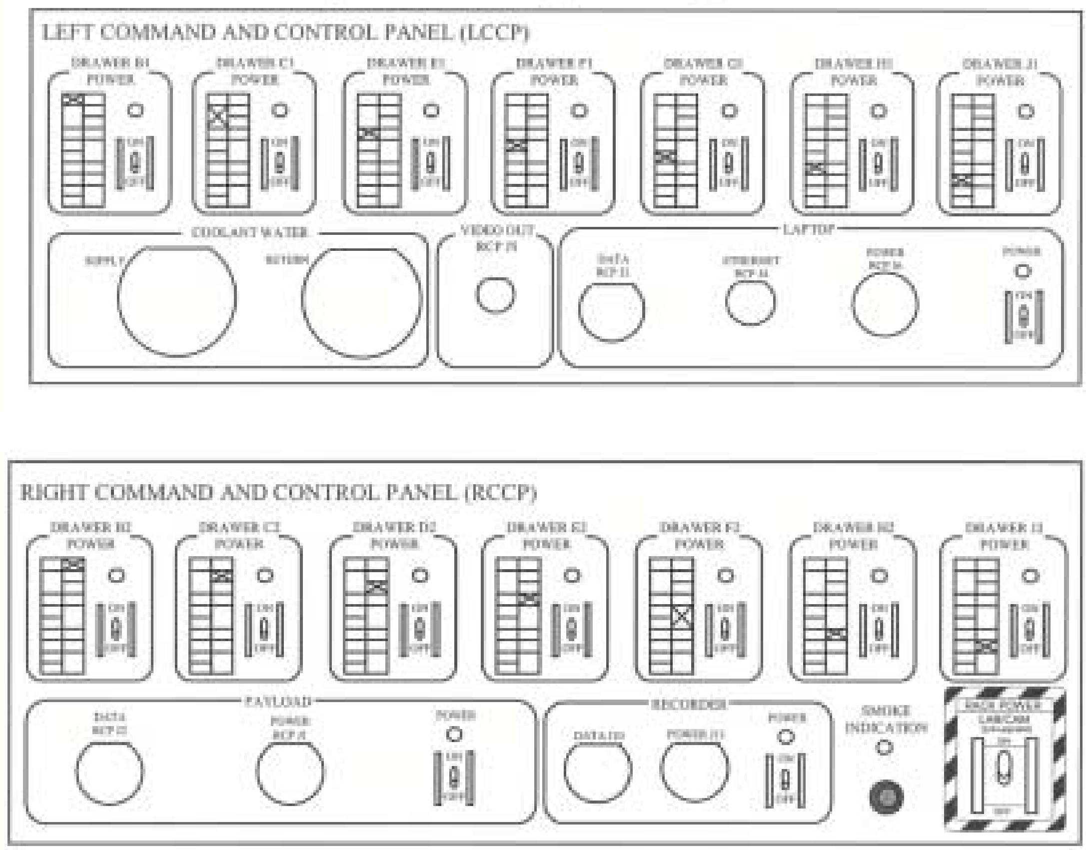


Figure 53. <u>Control Panel Labeling</u>

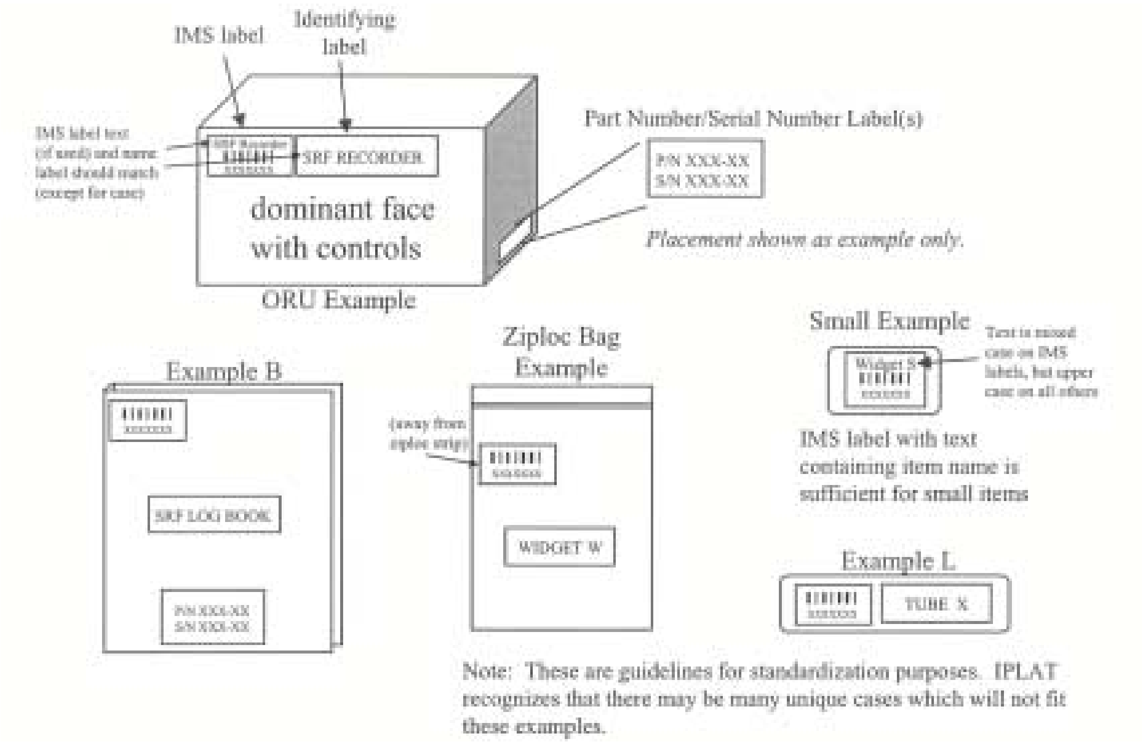


Figure 54. Miscellaneous Label Placement Examples

C.3.5.4 Equipment Labeling

C.3.5.4.1 Equipment Identification

a. All items on a payload must be identified with a label, including, but not limited to: displays, controls, switches, connectors, LEDs, containers, vents, etc., such that these items can be clearly referenced in crew procedures. Only those items whose use is obvious to the crew (e.g., food table, windows, etc.) are exempt from this instruction. The font size for these labels must be smaller than the main label naming the payload.

b. Containers must be labeled to identify their contents.

c. Loose equipment must be marked with nomenclature that describes the function of the item and its pertinent interfaces.

d. Multi–quantity Items

(1) Multi–quantity items that require individual distinction but are not serialized must be individually numbered. Controls level items should be logically numbered/lettered left to right or top to bottom in descending order (e.g. “DRIVE A”, “DRIVE B”, “DRIVE C”).

(2) Serial Numbers – Multi–quantity items that are serialized should display the serial number as part of the identification.

(3) Containers containing multiple quantities of the same item should use a number in parentheses, after the name, to indicate the quantity (i.e. ”TEST TUBES (4)”, indicates there are four test tubes in the container).

e. Logos – If organizational or commercial logo(s) are used, they must not be distracting to the crew while operating the payload. For front panels, the size of a logo should be smaller than the main name label.

C.3.5.4.2 EQUIPMENT CODING

C.3.5.4.2.1CABLE AND HOSE LABELING

a. Crew Interfce Cables and Hoses Definition – Electrical cables and hoses which are intended to be interfaced with by the crew for nominal operations (e.g. experiment operations), planned maintenance (e.g. ORU replacement), or are designed to have a crew interface in the event of a contingency situation, are considered “Crew Interface Cables and Hoses”, and are subject to the format requirements below.

b. Crew Interface Cables and Hoses must be labeled to indicate the equipment to which they belong and the connectors to which they mate.

(1) Electrical Cable End Plugs and Corresponding Electrical Connector Ports

a) The cable end plug must be designated with a “P” (e.g. P1), regardless of gender.
b) The connector port on the hardware must be designated with a ”J”, regardless of gender, and should be preceded by a descriptive name (e.g. DATA J1 or POWER J2).
c) The plug number and receptacle number for a mating pair should be identical (e.g. P1 mates with J1), except when not possible because a cable is generic.

(2) Cable and Hose Label General Characteristics

a) Font Size - The font size of the text on these labels should be 12 point preferred, or 10 point minimum.

b) Text/Background Color - The text should be black on a white background.

c) Abbreviations - When long names would result in an unreasonably large label, textcan be abbreviated.
d) Continuation Lines For Long Names – Long names are discouraged, but if necessary, additional lines can be added to the cable/hose identification and ends labels described below.

(3) Cable and Hose Identifying Labels

a) Cables and hoses must contain a main identifying label with the information below. This label must be placed at the mid-length position of the cable/hose, or at intervals not to exceed 2 meters for long utility lines. See Figure 55 for examples.

- The name of the cable/hose. For a hose, if the pressure is known and constant, it should be indicated in parentheses after the name (e.g. psi). The flow direction should be indicated with an arrow below the name if the hose ends are not interchangeable.

- The Part Number of the cable or hose

- The Serial Number of the cable or hose (if applicable)

(4) Cable and Hose IMS Labels – A cable/hose must contain one (and only one) IMS label. It must be placed to the left of the main identifying label, at the mid-length position, as shown in Figure 55. If the cable/hose requires multiple main identifying labels spaced at 2 meter intervals per #3 above, the IMS label should be placed at the center of the line.

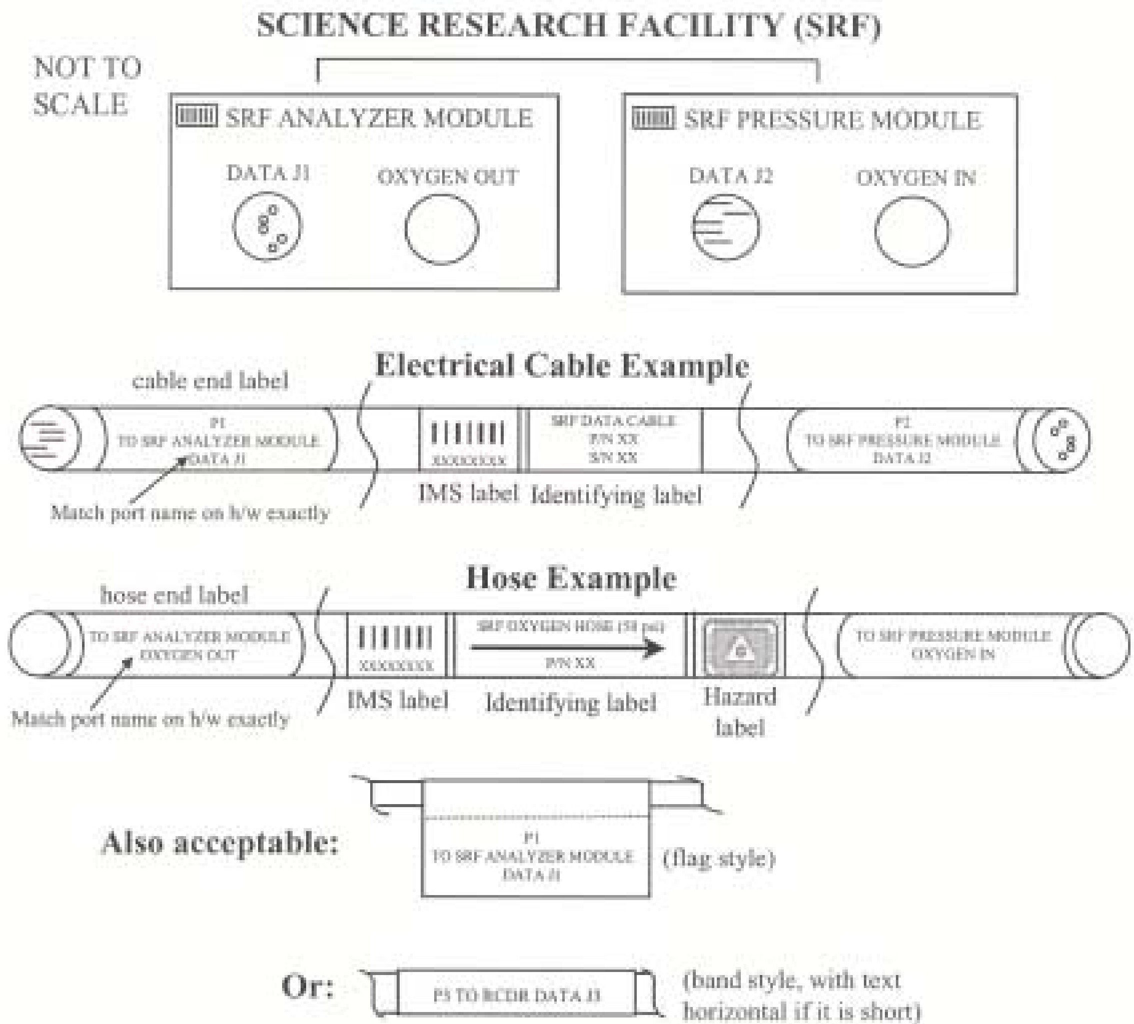
(5) Cable and Hose End Labels - Labels at the terminal ends of cables/hoses must contain the information below. Vertical order, center justified, is the preferred arrangement. When the circumference of the cable/hose is too small to accommodate a label that wraps around the line with text arranged vertically, a flag style label should be used. For cases where wear and tear of such flags is a concern (i.e. through frequent use), a horizontal arrangement of the information is allowed as long as the text is short. See Figure 56 for cable/hose label examples.

- First Line: The name of this end of the cable/hose (e.g. for cables, P1). For a hose, if the end does not have a specific identifier, this line may be left off. If the hose end needs to have a unique identifier, do not use a “P” number (“P”s are reserved for cables).

- Second Line: The word “TO” followed by the name of the piece of equipment to which this end of the cable/hose mates with. If this end can interface to multiple connector ports (e.g. generic cables), this line may be left off.

- Third Line: The exact name of the receptacle on the hardware that this end of the cable/hose mates with (e.g. DATA J1 or OXYGEN OUT). If this end can interface to multiple connector ports (i.e. generic cables), this line may be left off.

(6) Hose Hazard Labels – Hoses must have standard hazard class decals indicating the appropriate hazard level for the substance transported through the hose. This label must be placed to the right of the identifying label.



Notes:

Electrical cables/ports: "P" designates cable end plugs and "J" designates receptacles on hardware regardless of gender (pins/sockets).

Hose End Labels: The first line of the end label may be left off (as shown above) if the hose end does not have a specific identifier. In this case, only the second and third lines are needed. If hose ends must be identified, do not use a "P" number.

Hose Identifying Labels: Pressure should be indicated only if it is constant. Flow direction should be shown if the hose ends are not interchangeable.

Figure 55. Cable and Hose Labeling

C.3.5.4.2.2 COLOR CODING

a. Red must only be used to mark emergency use items. Yellow must only be used to mark Caution and Warning items. See section C.3.5.9 for Caution & Warning labeling requirements.

b. Hazard Labels – Hazard labels have their own, unique coding scheme, of which color is one factor. See Section C.3.5.9.i for instructions.

c. Identification/Connectivity – Color coding used for component identification or to denoteconnectivity relationships must combine color with nomenclature (i.e. hardware name and the payload it belongs to, simple number, part number, etc.) such that when those components are referred to within procedures, it is clear which components the procedures are referring to. The only color restriction is listed in paragraph A (red and yellow cannot be used).

d. Color Difference

(1) Only one hue within a color category (e.g., blues, greens) should be used on the decals or placards within the same integrated rack.

(2) That color must always be associated with a single meaning within the same system or integrated rack.

e. Number of Colors – No more than 9 colors, including white and black, must be used in a coding system.

f. Markings/Background Color – Markings and background colors on labels must have sufficient contrast such that the labels are readable in ambient ISS lighting conditions. Labels should adhere to the accepted combinations of markings and background color listed below:

Markings	Background
Black	White
Black	Yellow
Black	Silver (metalphoto labels)
White	Red
White	Black
White	Grey
Yellow	Blue
Red	White
Blue	Yellow

C.3.5.5 Location and Orientation

a. Subrack Location Codes:

1) At the Rack Level - Subrack location codes must be placed along the inside surface of the seat track at intervals equal to the individual rack's smallest drawer unit (e.g: 4 PU (7 inches) for U.S. payloads, different for IP racks). Each letter/number pair must be 18 point font and placed at the top of the particular drawer interval. Locations other than the inside of the seat track are permissible only if there is a permanent obstruction that would cover the labels.

2) For Control Panels That Control Multiple Subracks – Each subrack's controls must be mapped to its location using the letter/number code (e.g. "A1", "A2", "B1", "B2", etc.), and a graphic (matrix with appropriate box checked) showing the individual locker's location in the rack. See Figure 53 for examples.

b. Access Panels - maintenance access panels must be labeled to assist the crew in locating the panel for maintenance activities.

1) Access panel identification labels should be located in the upper left corner position on the panel with respect to the local vertical orientation.
2) Access panel identification labels for access panels on the side or back of a rack must be labeled:
a) The acronym for the rack (e.g. "SRF").
b) Its height location using the subrack location code (e.g. "C3") .
c) Its left, right, or back location on the rack preceded by a hyphen (e.g. "-L" for left, "-R" for right, "-B" for back).
For example, a completed access panel label might be "SRF C3-L" or "SRF C3-R".

c. Alignment Marks/Interface Identification

1) Alignment Marks – Alignment marks or other orientation markings must be used to aid the crew with the installation/mating of equipment when the hardware requires a specific orientation.

2) Visibility – Alignment marks, arrows, or other labels showing required orientation must be visible during alignment and attachment.

3) Tethered Equipment – Interface identification should not be used for movable items tethered to a mating part (e.g., dust cap for an electrical connector, hinged lid for a stowage container).

C.3.5.6 Operating Instruction

Operating instruction labels are hardware labels (affixed to hardware) that contain procedural steps. The procedural text should be coordinated with the PODF prior to final IPLAT approval and conform to ODF standards as documented in ODF Standards, SSP 50253. See Figure 56 for an example.

c. Location – Equipment operating instructions should be located on or adjacent to equipment.

d. Equipment Name – The instructions should have the title of the equipment to be operated centered above the text.

e. Grouping – Instructions should be grouped and titled by category (e.g., installation, removal, activation, calibration, etc.).

d. Title Selection – The titles of instructional text for equipment, displays, controls, switch positions, connectors, etc., must be in upper case letters only and bold.

(1) Title nomenclature must be consistent with procedural handbooks and checklists.

e. Instructional Text – Instructional text below titles must use upper and lower case letters. Direct references to hardware items should be in upper case so they match the hardware labels.

f. Required Tools – Instruction for removal of stowage items should list any tools required prior to the instructional text.

1) When tools are required to remove stowage items, markings should be used for the location of the fasteners to be removed.

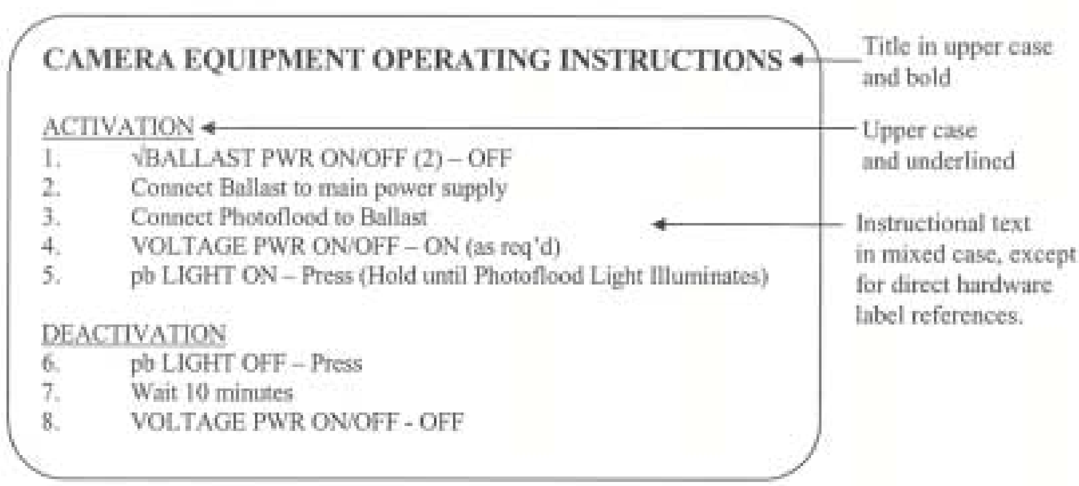


Figure 56 <u>Operating Instruction Label Example</u>

C.3.5.7 Stowage Container Labeling

This section applies to stowage containers provided by the payload, located within the payload, not in general ISS stowage containers.

- Each stowage container should display the contents on its front surface visible to the crewmember.

For drawer, box, or bag style stowage containers that are mounted as subracks as in Figure 57, the following requirements apply:

(1) The contents label should be as shown in Figure 57a when the location is known and fixed. The contents label should be as shown in Figure 57b when the location is not known or is variable.

(2) If the drawer/box/bag is being launched individually in the MPLM or the Space Shuttle Middeck, then the drawer must have the ascent label as shown in Figure 57c, in the front of the pocket. This label is then removed upon transfer to ISS, revealing the label in Figure 57a or 57b.

k. Provisions must be made to permit in-flight revisions to or replacement of stowage labels on all stowage containers.

l. Subdivided Containers:

   a. If a stowage container is subdivided internally into smaller closed containers, the sub-containers must carry a list of contents.

   b. If the available marking space on a sub-container is insufficient to display the complete content titles, a contents list must be displayed elsewhere and clearly identified as belonging to the sub-container.

   c. The specific contents of each sub-container and its code must be listed on the front surface of its container or near it.

a. Individual–Crew Items – Items allocated to a specific crewmember should be identified on the listing with the user's title, name, or other coding technique.

b. Similar Item Labeling – Containers with designated locations for placement of equipment set (e.g., socket wrenches in a tool kit) should have each location identified with the title of the item stowed.

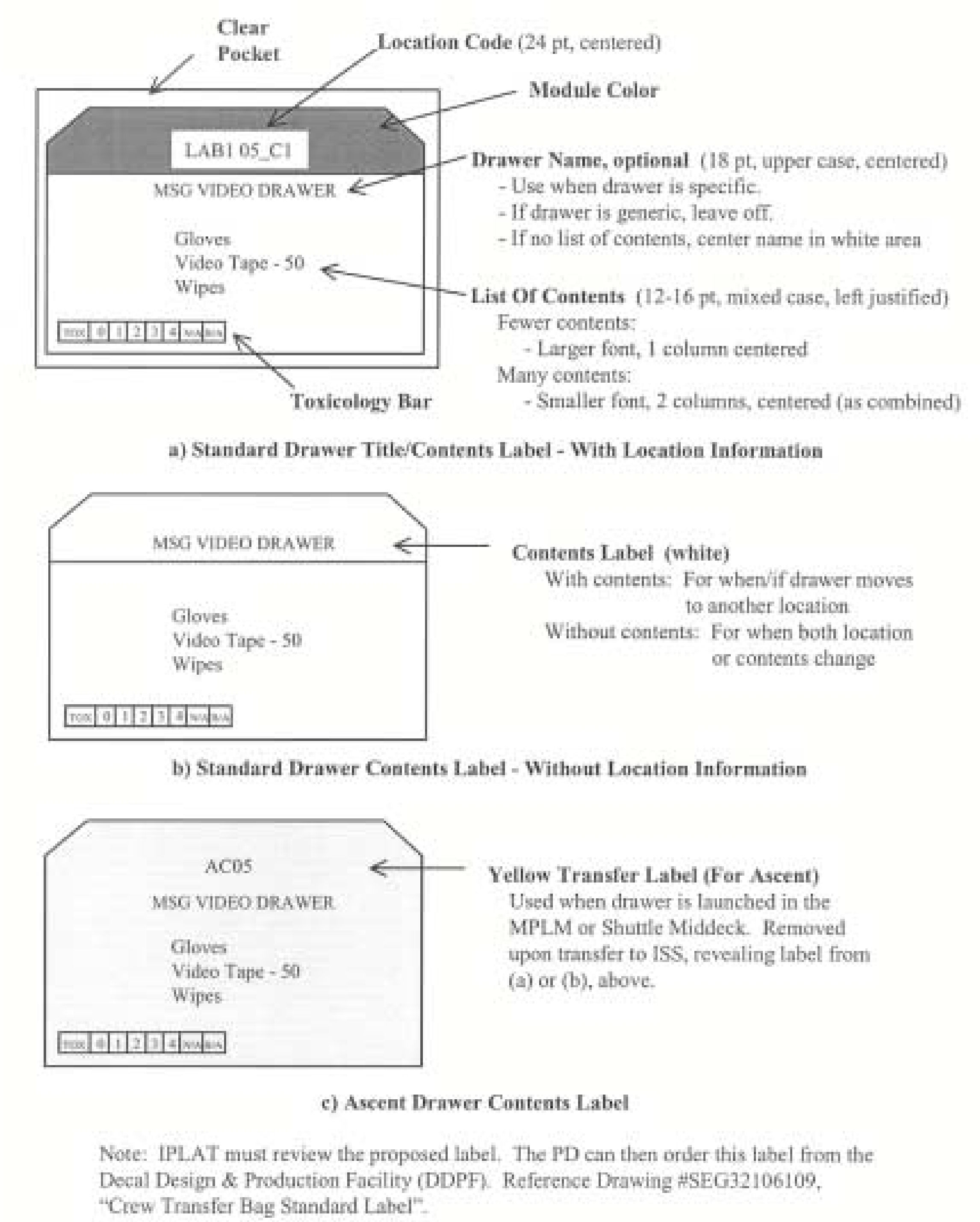


Figure 57 <u>Standard Payload Stowage Drawer Labels</u>

C.3.5.8 Grouped Equipment Items

a. Functional groups of three or more equipment items (i.e. displays, controls, switch positions, connectors, LEDS, etc.) must be identified (e.g., by common color, by boundary lines). Functional groups of equipment items are all associated or connected with a common system or purpose. (e.g., CABIN AIR, FURNACE A, EXPERIMENT “M”, PANEL LIGHTING). Two functionally related items should be grouped when such grouping provides clarification of purpose and/or distinquishes them from surrounding items. See Figure 58 for grouping label examples.

b. Labels must be located above the functional groups they identify.

c. When a line is used to enclose a functional group and define its boundaries, the labels must be centered at the top of the group, in a break in the line. When it is not possible to center the text at the top, the text may be placed elsewhere along the perimeter of the boundary line, but local vertical orientation or the text must be maintained.

(1) The width of the line must not be greater than the stroke width of the letters.

(2) The line must form an enclosed rectangle, or box, with rounded corners. Deviations from the rectangular shape are allowed when dimensional restrictions preclude a perfect rectangle.

d. When displays and controls are used together in adjustments or activation tasks, visible labels or markings must indicate their functional relationships.

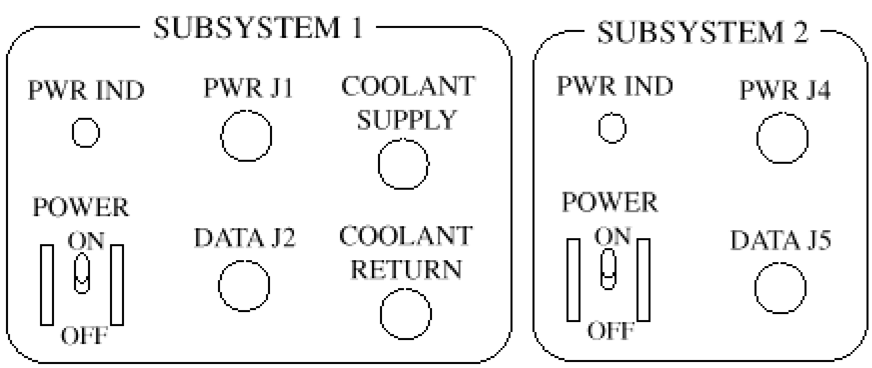


Figure 58. Grouping Label Example

C.3.5.9 Caution and Warning Labels

Caution and warning labels are required for indicating potentially undesirable conditions. See Figure 59 for examples.

a. Caution and warning labels must be standardized between and within systems.

b. Caution and warning labels must be distinct from one another.

c. Caution and warning labels must identify the type of hazard and the action that would prevent its occurrence.

d. The caution and warning markings must be located in a visible area.

e. Emergency-Use Items

(1) Labels on emergency-use items (e.g., repair kits, emergency lighting, fire extinguisher, etc.) must display the words "EMERGENCY USE" surrounded by diagonal red and white stripes either on the item or adjacent to it.

(2) The emergency type warning stripes must be alternate red and white.

(3) The red and white stripes should be of equal width.

(4) There must be no fewer than four red stripes and three white stripes.

(5) The striping must be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping must begin and end with a red stripe.

(7) The text must be white letters on the red background or red letters on a white background.

(8) For items located within a storage container, the diagonal striping must be applied to the door of the container and the titles of the emergency items must be included on the marking.

a. Caution And Warning Label Specifications

(1) Caution/warning decals and placards must be surrounded by diagonal yellow and black stripes.

(2) The caution/warning type stripes must be alternate yellow and black.

(3) The yellow and black stripes should be of equal width.

(4) There must be no fewer than four yellow stripes and three black stripes.

(5) The striping must be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping must begin and end with a yellow stripe.

(7) The text must be black letters on the yellow background.

a. Switches and Buttons

(1) The striping around a switch or button must not be wider than 25mm (1 in.) or narrower than 3 mm (0.125 in.).

(2) If one side of a switch or button has less than 3 mm (0.125 in.) space, no striping must be applied to that side.

a. Deleted

b. Hazard Labels

(1) Chemicals – The standard hazard class decals must be used to identify the proper hazard class of payload chemicals (i.e. chemicals in solid, liquid, or gaseous states), as deemed by the payload's toxicology representative. The developer may obtain these decals from JSC 27260, Decal Process Document and Catalog, or must produce identical labels. See NSTS 07700, Volume 14, Appendix 9, Section 5.6.3 for hazard class definitions.

(2) Other standard hazard decals that are found in JSC 27260, Decal Process Document and Catalog that must be used include: biological hazard, radiation hazard, sharps hazard (to be added), and batteries (to be added).

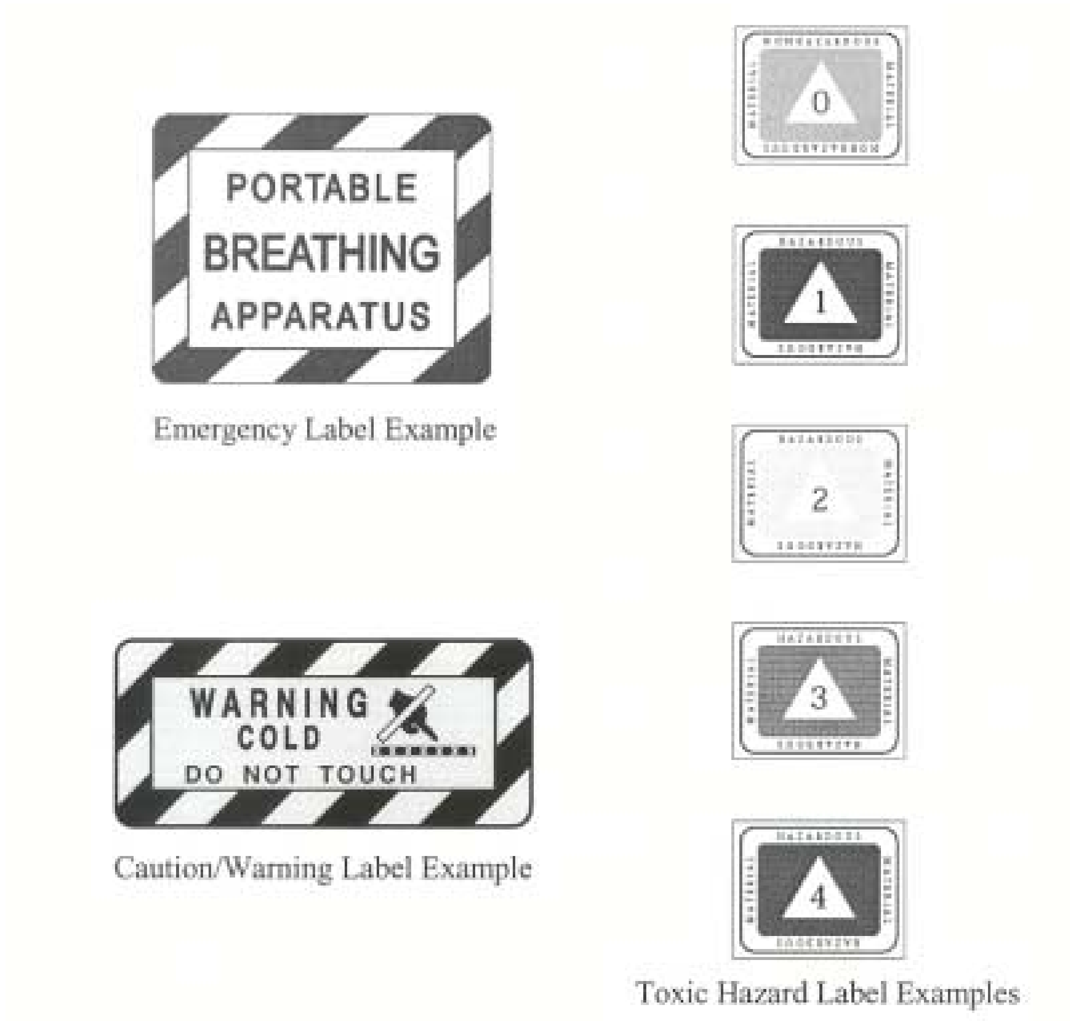


Figure 59. <u>Caution and Warning Label Examples</u>

C.3.5.10 Alphanumeric

C.3.5.10.1 Font Style

a. The font style used on decals, placards, and labels must be Helvetica or Futura demibold. If there are fit problems:

   (1) The use of condensed type (Helvetica Condensed) or abbreviations is the preferred method of solving line length.

   Or

   (2) For engraved markings which are not able to exactly match the above required font, the engraved marking should match the Helvetica font as nearly as possible.

Note: Helvetica is the preferred font.

d. Stenciled Characters – Stencil–type characters should not be used on display/control panels or other equipment.

C.3.5.10.2 Punctuation

a. Periods & Commas – Periods (.) and commas (,) should not be used in equipment labels, except to preclude misinterpretation.

b. Hyphens – Hyphens (–) should not be used in equipment labels, except in part numbers and serial numbers, and to preclude misinterpretation..

c. Parentheses and Ampersands – In general, parentheses and ampersands should not be used on payload equipment. Parentheses may be used to enclose acronyms after spelled out names (See Section C.3.5.3) and to designate multiple quantities of an item (See Section C.3.5.4.1.d.3). Ampersands may be used where the substitution of backslashes (/) would remove or distort the intended meaning (i.e. PUSH & HOLD vs. PUSH/HOLD).

d. Slashes – The backslash (/) may be used in place of the words ”and” and ”or” and may be used to indicate multiple functions.

C.3.5.10.3 Special Character

d. Subscript and Superscript Size – Subscripts and superscripts should be 0.6 to 0.7 times the height of associated characters.

e. Subscripts – Numeric subscripts and upper case letter subscripts should be centered on the baseline of associated characters.

f. Lower Case Letter Subscripts –The base of lower case letters and the ovals of g, p, q, etc., should be at the same level as the base of adjacent capital letters.

g. Degree Symbol – The degree symbol should be centered on an imaginary line extended from the top of the F or C symbols.

h. Pound or Number Symbol (#) – The pound or number symbol should be centered on an imaginary line extended from the top of the associated numerals and placed two stroke widths away from them.

C.3.5.10.4 Character Height

i. Character Height – Character height depends on viewing distance and luminance level. At a viewing distance of 710 mm (28 in.), the height of letters and numerals should be within the range of values given in Table XXXVII.

j. Variable Distance – For a distance (D) other than 710 mm (28 in.), multiply the values in Table XXXVII by D/710 mm (D/28 in.) to obtain the appropriate character height.

Table XXXVII. Character Height – 710 mm (28 in) Viewing Distance

Markings	Character Height	
	3.5 cd/m 2 (1ft–L) or below	Above 3.5 cd/m 2 (1ft–L)
For critical markings, with position variable (e.g., numerals on counters and settable or moving scales)	5–8 mm (0.20–0.31 in.)	3–5 mm (0.12–0.20 in.)
For critical markings, with position fixed (e.g., numerals on fixed scales, controls, and switch markings, or emergency instructions)	4–8 mm (0.16–0.31 in.)	2.5–5 mm (0.10–0.20 in.)
For noncritical markings (e.g., identification labels, routine instruc-tions , or markings required only for familiarization)	1.3–5 mm (0.05–0.20 in.)	1.3–5 mm (0.05–0.20 in.)

c. Size Categories – Characters used in hierarchical labeling (e.g. rack name, subrack name, controls groupings, port names, etc.) should be graduated in size. There should be at least a 25 percent difference in the character height between each of these categories.

d. Space Limitations – The use of the same size letters and numerals for all categories on a label is acceptable for solving space limitation and clarity problems. The height of lettering and numerals should be not less than 3 mm (0.12 in.).

C.3.5.10.5 Character Width

— Letters – The width of letters should be 0.6 of the height, except for the letter ”I,” which should be one stroke in width, the letters ”J” and ”L”, which should be 0.5 of the height, the letter ”M”, which should be 0.7 of the height, and the letter ”W,” which should be 0.8 of the height.

— Numerals – The width of numerals should be 0.6 of the height, except for the numeral ”4”, which should be one stroke width wider and the numeral ”1”, which should be one stroke in width.

— Wide Characters – When wider characters are used on a curved surface, the basic height–to–width ratio should be increased to 1:1.

C.3.5.10.6 Stroke Width

- Height–to–Stroke Ratio – Marking letters and numerals should have a height–to–stroke ratio of 5:1 to 8:1.

- Transillumination Background – Opaque markings on a transilluminated lighted background should have a height–to–stroke ratio of 5:1 to 6:1.

- Transilluminated Markings – Transilluminated markings on a dark background or markings used on integrally lighted instruments should have a height–to–stroke ratio of 7:1 to 8:1.

- General Purpose Illumination – Characters used on display panels and equipment when viewed under general purpose flood lighting or normal display conditions should have a height–to–stroke ratio of 6:1 to 7:1.

C.3.5.10.7 Character Measurement

c. Measurement – All letters and numeral measurement should be made from the outside edges of the stroke lines for other than machine engraving on opaque surfaces.

d. B. Engravings – For all mechanical engraving on opaque surfaces, the dimensions controlling the size of letters and numerals should be measured from centerline to centerline of the stroke.

C.3.5.10.8 Space

a. Character Spacing – The spacing between letters within words and between digits in a multi–digit number should be the equivalent of one stroke width between two straight–sided letters such as H and l. (This instruction intended to accommodate the normal commercial typographical practice of spacing letters to achieve a, consistent visual continuity. This permits close spacing of open letters such as C and T to avoid large apparent gaps.)

b. Word Spacing – The spacing between words should be the equivalent of the letter W between two straight–sided letters such as N and F.

c. Line Spacing

(1) The spacing between lines of related text should be 0.5 of upper case letter height.

(2) Spacing between headings and text should be 0.6 to 1.0 of upper case letter height.

C.3.5.11 Bar Coding

The investigation will work with the IIT for IMS label registration.

a. Racks, subracks, stowage trays, loose equipment, consumables, and ORUs must have an inventory management label in accordance with SSP 50007. IMS labels, or their placeholders, must be present on engineering drawings. If the PD orders their IMS labels from the DDPF, the Decal Catalog decal part number should be included in a note on the engineering drawing.

b. Delted

c. Deleted.

C.3.6 Deleted (Incorporated into C.3.5.4.2.2)

C.3.7 Scale Marking

a. Accuracy

(1) The precision of scale marking should be equal to or less than the precision of the input signal.

(2) In general, scales that are to be read quantitatively to the nearest graduation mark should be designed so that interpolation between graduation marks is not necessary. Interpolation should be limited to one half the distance between minor graduation marks.

(3) Scales should have a zero reference.

(4) If precise measurements are needed, scale graduation marks should be marked clearly to allow for unambiguous measurements.

a. Interval Values

(1) The graduation intervals should progress by 1, 5, or 2 units of decimal multiples thereof, in that order of preference.

(2) The number of graduation marks between numbered graduation marks should not exceed 9.

a. Scale Markings (High Luminance – above 1 ft–L)

(1) The minimum width of major, intermediate, and minor marks should be 0.32 mm (0.0125 in.)

(2) The length of major, intermediate, and minor graduation marks should be at least 5.6mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.09 in.), respectively.

(3) The minimum distance between major graduation marks should be 13 mm (0.5 in.).

(4) Minor graduation marks may be spaced as close as 0.89 mm (0.035 in.), but the

distance should be at least twice the stroke width for white marks on black dial faces and at least one stroke width for black marks on white dial faces.

a. Scale Markings (Low Luminance – below 1 ft–L)

(1) The minimum width of a major graduation should be 0.89 mm (0.035 in.), the minimum width of an intermediate graduation should be 0.76 mm (0.030 in.), and the minimum width of a mirror graduation should be 0.64 mm (0.025 in.).

(2) The length of major, intermediate, and minor graduation marks should be at least 5.6 mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.10 in.), respectively.

(3) The minimum distance between major graduation marks should be 16.5 mm (0.65 in.).

(4) Graduation marks should be spaced a minimum of 1.5 mm (0.06 in.) between centerlines.

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Appendix D

Table D1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (page 1 of 3)

Gas	Max Concentration	Additional Constraint
Acetaldehyde	100%	
Acetic Acid	100%	
Acetonitrile	100%	
Acetylene	100%	
Acrolein	100%	
Acrylonitrile	100%	
Argon	100%	
Benzene	100%	Note 3
Benzonitrile	100%	Note 3
1,3-Butadiene	100%	
n-butane	100%	
Butene	100%	
1-Butene	100%	
2-Butanone	100%	
Cabin Air	100%	
Carbon Dioxide	100%	
Carbon Monoxide	100%	
Chlorobenzene	100%	Note 3
Chloroethane	100%	
Chloromethane	100%	
cis-2-Butene	100%	
1,3-Cyclopentadiene	100%	
Cyclopentanone	100%	Note 3
Cyanogen chloride	100%	
Cyanogen bromide	100%	Note 3
n-Decane	100%	Note 3
1,1-Dichloroethane	100%	Note 3
1,1-Dichloroethene	100%	Note 3
Dichloromethane	100%	Note 3
Ethane	100%	
Ethene	100%	
Ethanol	100%	
Ethyl benzene	100%	Note 3
Ethyl isopropyl ether	100%	Note 3
Ethyl methyl ether	100%	
2-Ethyl-4-Methyl-1,3-Dioxolane	100%	Note 3

Table D1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (page 2 of 3)

Gas	Max Concentrate	Additional Constraint
Ethyl n-Propyl Ether	100%	Note 3
Formaldehyde	100%	
Helium	100%	
n-hexanal	100%	Note 3
Hexane	100%	Note 3
Heptane	100%	Note 3
Hydrogen	100%	
Hydrogen cyanide	100%	
Hydrogen sulfide	100%	
Isopropanol	100%	
Isopropyl formate	100%	Note 3
Krypton	100%	
Methane	100%	
Methanol	100%	
Methyl acetate	100%	
Methyl acrylate	100%	Note 3
2-Methyl-2-butenal	100%	Note 3
1-(1-Methylethoyx)-2-Propanone	100%	Note 3
Methyl formate	100%	
Methyl methacrylate	100%	Note 3
2-Methyl propane	100%	
2-Methyl propenal	100%	
2-Methyl propene	100%	
Mixtures of gases in Appendix D1		Note 2
Neon	100%	
Nitrogen	100%	
Norflurane	100%	Note 3
Octane	100%	Note 3
o-Xylene	100%	Note 3
Oxygen	(not more than 30% by volume vented from the experiment chamber)	
Pentanal	100%	Note 3
Pentane	100%	
Propadiene	100%	
Propane	100%	
Propanol	100%	

Table D1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (page 3 of 3)

Gas	Max Concentration	Additional Constraint
2-Propanone	100%	
Propene	100%	
n-Propyl acetate	100%	Note 3
Propyl formate	100%	Note 3
n-Propyl isopropyl ether	100%	Note 3
Propyne	100%	
Radon	100%	
Styrene	100%	Note 3
Sulfur Dioxide	100%	
Sulfur hexafluoride	100%	Note 3
tert-Butyl alcohol	100%	
Toluene	100%	Note 3
1,1,1-Trichloroethane	100%	Note 3
Trichlorofluoroethane	100%	Note 3
1,2,4-Trimethylbenzene	100%	Note 3
2,2,4-Trimethyl-1,3-dioxolane	100%	Note 3
Vinyl acetate	100%	Note 3
Vinyl Chloride	100%	
Water Vapor	100%	
Xenon	100%	
m-Xylene	100%	Note 3

Note 1: Vented cabin air will contain small percentages of additional gases at up to the maximum levels defined in SSP41000, Table VII, Spacecraft Maximum allowable concentrations (SMAC), or NHB 8060.1B, Appendix D. If gases are not referenced in the above documents, the Investigator shall use the Materials and Processes Technical Information System (MAPTIS) SMAC values, including the date the information was taken form MAPTIS, as MAPTIS is not under configuration control. Cabin air particulates are limited to levels identified in SSP 41000, paragraph 3.2.1.1.1.15.

Note 2: Combinations of all gases must be analyzed and are constrained as specified to paragraph 3.5.1.5, this table only represents the gases that are compatible with the USL VES wetted materials.

Note 3: Each proposed vent gas with a molecular weight greater than 75 amu shall be analyzed in accordance with 3.5.1.5.2.

Table D2 EXHAUST GASES NOT COMPATIBLE WITH THE USL VES WETTED MATERIALS

Gas	Notes
Hydrogen bromide	Note 1
Hydrogen chloride	Note 1
Hydrogen fluoride	Note 1
Hydrogen iodide	Note 1
Nitric acid	Note 1
Nitrogen dioxide	Note 1
Nitrogen tetroxide	Note 1
Perchloric acid	Note 1
Phosgene	Note 1
Phosphoric acid	Note 1
Sulfuric acid	Note 1

Note 1: These gases shall be containerized, stored, or transported by the investigation, unless the concentrations of the gases are no more than the maximum levels defined in SSP41000, Table VII, SMAC or NHB 8060.1B, Appendix D. If gases are not referenced in the above documents, the Investigator shall use the Materials and Processes Technical Information System (MAPTIS) SMAC values, including the date the information was taken form MAPTIS, as MAPTIS is not under configuration control.

APPENDIX E
VERIFICATION DEFINITION SHEETS

This appendix contains the Verification Definition Sheets (VDS). The VDS provide the complete set of verification requirements necessary to ensure compliance with the interface and design requirements contained in section 3. The verification requirements in the Appendix shall be complied with by all MSG Investigations.

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ST-001	STRUCTURAL - STRUCTURAL STRENGTH	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.1.1.c Loads Requirements (A)

Requirement Summary:
The investigation must be able to withstand loads due to on-orbit accelerations as specified.

Detailed Descriptions of Requirements:

On-orbit loads shall be based on the 0.2G acceleration acting in any direction.

Required Verification Data:	Data Submittal Dates:
1. Data Cert that provides a summary of the analysis showing positive margins of safety.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.1.1.3.B

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ST-002	STRUCTURAL - CREW-APPLIED LOADS	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.1.1.d Loads Requirements (A)

Requirement Summary:

This requirement addresses the ability of investigation hardware to withstand crew-applied loads for all operational modes.

Detailed Descriptions of Requirements:

Verify the capability of all investigation hardware that has a potential interface with the crew for operation, use, or impact (whether inadvertent or not) to withstand crew applied loads as specified in paragraph 3.1.1.1.d. Verify by stress analysis, using appropriate factors of safety, that all structures have positive margins of safety.

Required Verification Data:	Data Submittal Dates:
1. Data Cert providing a summary listing of all operational modes analyzed and showing positive margins of safety.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.1.1.3.D

NSTS.1700.7

NSTS-21000-IDD-MDK

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ST-003	STRUCTURAL - ON-ORBIT DEPRESS/REPRESS	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.1.2.b Additional Investigation Requirements (A)

Requirement Summary:

This requirement addresses the ability of the investigation to withstand pressure buildup during depressurization/repressurization.

Detailed Descriptions of Requirements:

An analysis shall be conducted which shows the investigation's ability to withstand the depress rate of 878 Pa/sec (7.75 psi/min) and repress rate of 800 Pa/sec (6.96 psi/min).

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.1.1.4.B

NSTS-21000-IDD-MDK

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ST-005	STRUCTURAL - HUMAN FACTOR STRENGTH REQUIREMENT	ISS	A or D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.1.a Strength Requirements (A or D)
3.10.1.b Strength Requirements (A or D)
3.10.1.c Strength Requirements (A or D)

Requirement Summary:

These requirements ensure that the crew will be physically capable of removing, replacing, controlling, operating, and maintaining the investigation hardware and equipment on-orbit.

Detailed Descriptions of Requirements:

A. Grip Strength - Verify by analysis or demonstration that the grip strength required to remove, replace, and operate the investigation equipment is less than 254 N (57 lbf).

B. Linear Forces - Verify by analysis or demonstration that the linear forces required to remove, replace, and operate the investigation equipment are less than the strength values for the 5th percentile female, defined as 50% of the strength values as specified in MSFC-RQMT-2888, Figure 32.

C. Torsional Forces - Verify by analysis or demonstration that the torsional forces required to remove, operate, and replace the investigation equipment are less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability as specified in MSFC-RQMT-2888, Figure 33.

Note: These requirements can be closed during crew training by crew usability acceptance.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC)	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.1 and Figures 3.12.1-1, 3.12.1-2, 3.12.1-3, 3.12.1-4, and 3.12.1-5

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ST-009	STRUCTURAL - SECURING OF THREADED FASTENERS	ISS	A or I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.8.4.7 Locking Wires (I)

Requirement Summary:

Safety wires may not be used on fasteners.

Detailed Descriptions of Requirements:

Safety/lock wire is excluded as an acceptable method for securing of threaded fasteners.

Verification shall be considered successful when an inspection of threaded fasteners shows that safety/lock wires were not used.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

MS 33540
SAE AS4536
SSP 52005, par. 5.6
SSP 57000, par. 3.12.9.9 and 3.1.1.5
NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-001	MECHANICAL – WEIGHT, CG & GEOMETRY	IIT	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.1.2.a Additional Investigation Requirements (A&T)
3.1.3 Stowage Input Requirements (T&A)

Requirement Summary:

This requirement ensures that the weight of each investigation is within specified limits.

Detailed Descriptions of Requirements:

Determine the actual weight of investigation hardware items by analysis based on test data. Allowable tolerance of weighing equipment shall be ±0.05 lb. The actual mass of the investigation hardware items shall be no greater than the mass specified in the unique investigation ICD.

Determine the actual center of gravity (cg) in three orthogonal axes for hardware items greater than 30 lbs (13.6 kg) being stowed in the middeck and 50 lbs (22.7 kg) in the MPLM by test. Verification shall be considered successful when drawings are submitted to the IIT showing cg locations and origin. The accuracy shall be ± 0.5 in. (1.27 cm) for actual measured cg coordinate.

Determine by analysis the moment of inertia with respect to x, y, z axes about the cg (Ixx, Iyy, Izz) in kg-cm^2 and the product of inertia with respect to the x & y, y & z, x & z axes about the cg (Ixy, Iyz, Ixz) in kg-cm^2 for hardware items over 50 lbs (22.7 kg). They shall have an accuracy of ± 5%.

Verify that the hardware items size, shape and volume identified in the ICD are correct. Verification shall be considered successful when a COC is submitted stating that the size, shape and volume of the investigation hardware items in the ICD are correct.

NOTE: The IIT will determine that the investigation weight and any provided ancillary equipment meets the on-orbit requirement.

Required Verification Data:	Data Submittal Dates:
Data cert that provides weight for launch and landing of the investigation hardware items. 1. Drawings showing cg locations and origin. 2. Analysis for the moment and product of inertia. 3. Certificate of Compliance (COC).	1. L-8 2. L-8 3. L-8 4. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.1.1.4.A
NSTS-21000-IDD-MDK

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-003	MECHANICAL - PAYLOAD IN-FLIGHT MAINTENANCE	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.9 Payload In-Flight Maintenance (A)

Requirement Summary:

This requirement ensures that investigation hardware can be maintained using Space Station-provided on-board tools.

Detailed Descriptions of Requirements:

Investigation hardware designed to be maintainable shall use Space Station-provided on-board tools. The verification shall be considered successful when an analysis of payload hardware and flight drawings confirm that the hardware can be maintained using Space Station-provided on-board tools, see section 3.10.9.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.10
SSP 57020, (Pressurized Payloads Accommodations Handbook (TBD))

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-007	MECHANICAL - CLOSURES AND COVERS	ISS	A&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.2.1.1 Closures and Covers (I)
3.10.8.4.1 Holes (A&I)

Requirement Summary:

Closures and covers are required for areas that are not designed for routine cleaning.

Detailed Descriptions of Requirements:

A. Closures or covers shall be provided for any area of the investigation equipment that is not designed for routine cleaning. Verification shall be performed by inspection of the investigation drawings to verify the design and by inspection of the flight hardware to confirm compliance with the requirement. (MSFC-RQMT-2888 Paragraph, 3.10.2.1.1)

B. Covers shall be provided for holes that are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in.) (MSFC-RQMT-2888 Paragraph 3.10.8.4.1). An analysis shall be performed using data from drawings to identify the applicable holes. Verification shall be performed by inspection of the design drawings to ensure that either proper hole sizes have been used or that all applicable holes are covered or guarded.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.	A&I	

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.3.1.1, 3.12.4.2.8.1, 3.12.4.2.8.2, and 3.12.9.3

NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-008	MECHANICAL - BUILT-IN CONTROLS	ISS	I & D or A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.2.1.2.a Built-In Controls (I)
3.10.2.1.2.b Built-In Controls (A or D)

Requirement Summary:

Containers of liquids or particulate matter must have built-in methods of capture control, and the capture mechanisms/elements should not disperse their trapped materials while they are being replaced or cleaned. Also, payload-provided cleaning materials must meet specific requirements.

Detailed Descriptions of Requirements:

A. Payload containers of liquids or particulate matter shall have built-in equipment/methods for control of vaporization, material overflow, or spills. (MSFC-RQMT-2888, Paragraph 3.10.2.1.2.a) Verification shall be performed by inspection of the drawings to verify the design and by inspection of the flight hardware to confirm compliance with the requirement.

B. Capture elements, including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials. (MSFC-RQMT-2888, Paragraph 3.10.2.1.2.b). The verification shall be considered successful when demonstration or analysis shows that the crew can access the flight hardware capture elements for cleaning or replacement without dispersion of trapped material.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.12.3.1.2
NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-009	MECHANICAL - ONE-HANDED CLEANING OPERATIONS	ISS	D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.2.1.3 One-Handed Operation (D)

Requirement Summary:

Investigation cleaning equipment and supplies must be designed for one-handed operation or use.

Detailed Descriptions of Requirements:

Verify by demonstration that investigation cleaning equipment and supplies can be operated using only one hand, which does not preclude the use of either hand.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.12.3.1.5

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-011	MECHANICAL - EQUIPMENT MOUNTING	ISS	A or D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.1 Equipment Mounting (A or D)

Requirement Summary:

Equipment must be labeled or marked to protect against improper installation.

Detailed Descriptions of Requirements:

Equipment mounting used during nominal operations and planned maintenance shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the payload hardware used during nominal operations and planned maintenance is designed, labeled, or marked to protect against improper installation.

NOTE: The demonstration can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC), stating no changes have been made to the hardware since testing was performed.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.2.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-016	MECHANICAL - UNIQUE TOOLS	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.2 Unique Tools (A)

Requirement Summary:

Investigation-provided unique tools must comply with MSFC-RQMT-2888 requirements.

Detailed Descriptions of Requirements:

Investigation-provided unique tools and power tools shall meet the requirements in MSFC-RQMT-2888 paragraph 3.10.3.2. Verification shall be considered successful when an analysis of the payload flight hardware drawings for investigation-provided unique tools shows that the tool requirements are met based on the identified requirements in the Investigation Verification Matrix.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 50005, par. 11.2.3
SSP 57000, par. 3.12.4.2.8.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-017	MECHANICAL-CONNECTOR MATING/DEMATING	ISS	A&D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.3.3.1 One-Handed Operation (D)
3.10.3.3.3 Ease of Disconnect (A)
3.10.3.3.4 Self Locking (A)

Requirement Summary:

These requirements ensure that fluid and electrical connectors can be operated easily by crewmembers on-orbit. Fluid connectors must be designed for one-handed operation. The crew should be able to disconnect electrical connector plugs by no more than two turns, and internal connector plugs must provide a self-locking safety catch.

Detailed Descriptions of Requirements:

A. Fluid Connectors
All investigation connectors, whether operated by hand or tool, shall be designed so that they can be mated/demated using one hand. Connector design shall not preclude the use of either the right or the left hand. (MSFC-RQMT-2888, Paragraph 3.10.3.3.1) Verification shall be considered successful when the demonstration shows that all investigation connectors (flight hardware or hardware that replicates the flight hardware configuration), can be mated/demated using only one hand, which does not preclude the use of either hand.

B. Electrical Connectors
   i. All investigation connectors, whether operated by hand or tool, shall be designed so that they can be mated/demated using one hand. Connector design shall not preclude the use of either hand. (MSFC-RQMT-2888, Paragraph 3.10.3.3.1). Verification shall be considered successful when the demonstration shows that all investigation connectors can be mated/demated using only one hand, which does not preclude the use of either hand.
   ii. Electrical connectors which are mated/demated during nominal operations shall require no more than two turns to disconnect (MSFC-RQMT-2888, Paragraph 3.10.3.3.3). Ease of disconnect shall be verified by analysis. Verification shall be considered successful when an analysis shows that electrical connectors which are mated/demated during nominal operations require no more than two turns to disconnect.
   iii. Payload electrical connectors shall provide a self-locking feature. (MSFC-RQMT-2888, Paragraph 3.10.3.3.4) Verification shall be considered successful when an analysis of payload flight hardware drawings shows payload electrical connectors are provided with a self-locking feature.

NOTE: Demonstration shall be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.3.1, 3.12.4.3.3, and 3.12.4.3.5

NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-018	MECHANICAL - CONNECTOR ARRANGEMENT AND ACCESSIBILITY	ISS	D & I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.3.3.2 Accessibility (D)
3.10.3.3.5 Connector Arrangement (I)

Requirement Summary:
Connectors must be accessible, and they should be easy to disconnect, or reconnect without causing damage to them.

Detailed Descriptions of Requirements:

A. Accessibility shall be verified by demonstration. Verification shall be considered successful when the demonstration of the payload flight hardware shows that it is possible to mate/demate individual connectors without having to remove or mate/demate other connectors.

B. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors. Verification shall be considered successful when an analysis of the payload hardware drawings shows that it is possible to disconnect and reconnect electrical connectors and cable installations without damage to wiring connectors.

C. Space between connectors and adjacent obstructions shall be a minimum of 25 mm (1 inch) for access. Verification shall be considered successful when an inspection of the space between connectors and adjacent obstructions shows compliance with the requirement.

D. Connectors in a single row or staggered rows which are removed sequentially by the crew shall provide a minimum of 25 mm (1 inch) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence. Verification shall be considered successful when an inspection of connectors in a single row or staggered rows shows compliance with the requirements.

NOTE: Demonstration shall be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.3.2 and 3.12.4.3.6

Number	Title	Purpose	Method	Hazard Report(s)
ITT-ME-019	MECHANICAL - CONNECTOR PROTECTION AND SHAPE	ISS	A & DorI	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.3.7 Connector Protection (A)
3.10.3.3.8 Connector Shape (A)
3.10.8.2 Mismatched (D or I)

Requirement Summary:

Investigation connectors should be designed to prevent inadvertent reversing or mismatching of electrical connections.

They should also have sufficient mechanical protection to prevent crewmember contact with exposed electrical contacts, and physical damage/contamination protection should be provided for demated connectors.

Detailed Descriptions of Requirements:
Connectors

i. Physical - Protection shall be provided for all demated connectors against physical damage and contamination. (MSFC-RQMT-2888 Paragraph 3.10.3.3.7). Verification shall be considered successful when an analysis shows that protection is provided for all demated connectors against physical damage and contamination.

ii. Mismating - The design of investigation connectors shall be verified by analysis and demonstration or inspection. The demonstration shall be performed on the investigation connectors. The analysis and inspection shall be performed on the drawings. The verification shall be considered successful when the analysis and demonstration or inspection shows that the connectors are unique to its appropriate connection, thereby preventing mismatching. See MSFC-RQMT-2888 Paragraph 3.10.3.3.8 and 3.10.8.2.

NOTE: Demonstration can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.3.8, 3.12.4.3.9, and 3.12.9.1.1

NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-020	MECHANICAL - ALIGNMENT, CODING, AND ORIENTATION	ISS	A&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.3.13 Alignment Marks or Guide Pins (I)
3.10.3.3.12 Orientation (A)
3.10.3.3.10 Coding (I)

Requirement Summary:

Parts that are to be mated on-orbit must have alignment marks with both halves properly coded, and grouped plugs must be oriented so that aligning pins are in the same relative position.

Detailed Descriptions of Requirements:

A. Alignment marks, guide pins, or mating parts shall be verified by inspection. The inspection shall be performed by examining the mating hardware for alignment marks or guide pins in a visible location during mating. Verification shall be considered successful when an inspection shows that the alignment marks or guide pins are applied to mating parts and consist of a straight or curved line to a width and length sufficient to allow accurate alignment. Guide pins shall be verified by inspection of the drawings or the hardware. The verification shall be considered successful when the guide pins are shown to extend beyond the plug's electrical pins to ensure that guide is obtained before the electrical pins engage.

B. Both halves of mating connectors shall display a code or identifier which is unique to that connection. The labels or codes on connectors shall be located so that they are visible when connected or disconnected. (MSFC-RQMT-2888, Paragraph 3.10.3.3.10) Verification shall be considered successful when an inspection shows that both halves of mating connectors display a code or identifier which is unique to that connection.

C. Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position. (MSFC-RQMT-2888, Paragraph 3.10.3.3.12) Verification shall be considered successful when an analysis of the payload flight hardware drawings shows that grouped plugs and receptacles are oriented so that the aligning pins or equivalent devices are in the same relative position.

NOTE: Inspection shall be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.	A&I	

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.3.11, 3.12.4.3.12 , and 3.12.4.3.14

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-023	MECHANICAL - ENGAGEMENT STATUS INDICATION	ISS	D or I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.3.4.1 Non-Threaded Fastener Status Indication (D or I)

Requirement Summary:

Non-Threaded fasteners must provide an indication that they are correctly engaged.

Detailed Descriptions of Requirements:

Non-threaded fasteners status indication shall be verified by demonstration or inspection. Verification shall be considered successful when the demonstration or inspection shows that an indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-024	MECHANICAL - MOUNTING BOLT/FASTENER SPACING AND TOOL CLEARANCE	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.4.2 Mounting Bolt/Fastener Spacing (I)
3.10.3.4.12 Access Holes (I)

Requirement Summary:

Spacing around fasteners must allow hand or tool access, and holes that fasteners pass through should not require precise alignment of the fastener. Adequate clearance for finger access must be provided.

Detailed Descriptions of Requirements:

A. Mounting bolts and fasteners shall be spaced the required distance from other surfaces as specified in MSFC-RQMT-2888, Paragraph 3.10.3.4.2. Verification shall be considered successful when an inspection of the hardware shows that the required distances have been met.

B. Covers or shields through which mounting fasteners must pass shall have holes that allow passage of the fastener (and hand or necessary tool if either is required) without precise alignment. (MSFC-RQMT-2888, Paragraph 3.10.3.4.12) Verification shall be considered successful when an inspection shows that covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit have holes for passage of the fastener without precise alignment.

NOTE: Inspection shall be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.2, 3.12.4.4.13, and 3.12.4.4.14

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-025	MECHANICAL - MULTIPLE FASTENERS	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.4.3 Multiple Fasteners (I)

Requirement Summary:

When several fasteners are used on one item, they should all be of the same type (excluding length), and the design should prohibit them from being assembled incorrectly.

Detailed Descriptions of Requirements:

Multiple fasteners shall be verified by inspection. Verification shall be considered successful when an inspection shows that when several fasteners are used on one item they are all of identical type (excluding length).

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-026	MECHANICAL - FASTENERS	ISS	A&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.8.4.3 Screws and Bolts (A&I)
3.10.3.4.4 Captive Fasteners (A)
3.10.3.4.5 Quick Release Fasteners (I)
3.10.3.4.6 Threaded Fasteners (I)
3.10.3.4.8 Winghead Fasteners (I)

Requirement Summary:

These requirements ensure that fasteners in the investigation hardware comply with specified operational requirements.

Detailed Descriptions of Requirements:

A. All fasteners shall be captive when disengaged. (MSFC-RQMT-2888, Paragraph 3.10.3.4.4) Verification shall be considered successful when an analysis shows that fasteners that are planned to be installed and/or removed on-orbit are captive when disengaged.

B. Quick Release Fasteners shall:

  i. Require a maximum of one complete turn to operate (quarter-turn fasteners are preferred). (MSFC-RQMT-2888, Paragraph 3.10.3.4.5) Verification shall be considered successful when an inspection shows that fasteners require a maximum of one complete turn to operate.

  ii. Be positive-locking in the open and closed positions (MSFC-RQMT-2888, Paragraph 3.10.3.4.5). Verification shall be considered successful when an inspection shows that fasteners are positive-locking in open and closed positions.

C. Threaded fasteners shall have only right-hand threads (MSFC-RQMT-2888, Paragraph 3.10.3.4.6). Verification shall be considered successful when an inspection shows that threaded fasteners have right-handed threads per the hardware or drawings.

D. Winghead fasteners shall fold down and be retained flush with surfaces (MSFC-RQMT-2888, Paragraph 3.10.3.4.8). Verification shall be considered successful when an inspection shows that winghead fasteners fold and are retained flush with surfaces.

E. Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in.) shall be capped to protect against sharp threads. (MSFC-RQMT-2888, paragraph 3.10.8.4.3) To satisfy the verification an analysis shall be performed using data from drawings, integration documentation, and operational procedures to identify screws and bolts that exceed the length specified in the requirements and the required use of guards or covers due to location in crewmember translation paths within the MSG work volume. The verification shall be considered successful when a drawing inspection shows that screws and bolts which exceed the specified length have been properly covered, or guarded.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

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Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-026	MECHANICAL - FASTENERS	ISS	A&I	

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Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 52005, section 5.6
SSP 57000, par. 3.12.4.4.5, 3.12.4.4.6, 3.12.4.4.7, 3.12.4.4.9, and 3.12.9.5
NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-027	MECHANICAL - LATCHES	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.5.2.a Stowage and Equipment Containers (I)
3.10.5.2.b Stowage and Equipment Containers (I)
3.10.8.4.2 Latches (I)
3.10.3.4.7 Over Center Latches (I)

Requirement Summary:

These requirements ensure that latches and associated handles/operating mechanisms comply with specified operational requirements.

Detailed Descriptions of Requirements:

A. Over center latches shall have the following design features:

i. Nonself-Latching - Over center latches shall include a provision to prevent undesired latch element realignment, interface, or re-engagement. (MSFC-RQMT-2888, Paragraph 3.10.3.4.7). Verification shall be considered successful when an inspection shows that there is a provision to protect against undesired latch element realignment, interface, or re-engagement.

ii. Latch Lock - Latch catches shall have locking features. (MSFC-RQMT-2888, Paragraph 3.10.3.4.7). Verification shall be considered successful when an inspection shows that latch catches have locking features.

iii. Latch Handles - If the latch has a handle, the latch handle and latch release shall be operable by one hand. (MSFC-RQMT-2888, Paragraph 3.10.3.4.7). Verification shall be considered successful when an inspection shows that the latch handle and latch release are operable by one hand.

B. Latches on containers shall include the following design features:

i. All latches, handles, and operating mechanisms shall be designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male to the 5th percentile female. (MSFC-RQMT-2888 Paragraph 3.10.5.2.a). Verification shall be considered successful when an inspection of the payload flight hardware drawings shows that all latches, handles, and operating mechanisms are designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male and accommodate the 5th percentile female.

ii. The design of latches shall be such that their status (locked/unlocked) can be determined through visual inspection. (MSFC-RQMT-2888 Paragraph 3.10.5.2.b). Verification shall be considered successful when an inspection shows that the status of latches can be determined through visual inspection.

C. Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4 in.) exists shall be designed to prevent entrapment of a crewmembers appendage. (MSFC-RQMT-2888 paragraph 3.10.8.4.2). Verification shall be considered successful when an inspection shows that all latches and similar devices have been properly covered, or guarded and designed to prevent entrapment of crewmember appendages.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

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Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-027	MECHANICAL - LATCHES	ISS	I	

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Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.8, 3.12.6.2, and 3.12.9.4

NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-028	MECHANICAL - FASTENER HEAD TYPE	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.4.9 Fastener Head Type (I)

Requirement Summary:

These requirements ensure that fastener head designs comply with operational requirements.

Detailed Descriptions of Requirements:

A. Hex type external or internal grip or combination-head fasteners type shall be verified by inspection. The inspection shall be of the drawings and parts list or of the flight hardware. Verification shall be considered successful when an inspection shows that the hex type external or internal grip or combination head fasteners are used for all on-orbit crew-actuated equipment.

B. Flush or oval head internal hex grip fasteners shall be used only where smooth surfaces are required. The inspection shall be of the flight hardware or the drawings and parts list. Verification shall be considered successful when an inspection shows that, when a smooth surface is required, only flush or oval head internal hex grip fastener head types are used.

C. The verification that straight-slot fasteners are not used to carry launch loads for hard mounted equipment shall be by inspection. The inspection shall be of the flight hardware or the drawings and parts list. The verification shall be considered successful when an inspection shows that straight-slot fasteners are not used to carry launch loads for hard mounted equipment.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.11

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-029	MECHANICAL - ONE-HANDED FASTENER ACTUATION	ISS	D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.4.10 One-Handed Actuation (D)

Requirement Summary:

One-handed operation (either left or right hand) should be sufficient to actuate fasteners.

Detailed Descriptions of Requirements:

One-handed actuation shall be verified by demonstration. The demonstration shall be performed on the flight hardware, or hardware which replicates the flight hardware configuration in the EU. Verification shall be considered successful when the demonstration shows that fasteners planned to be removed or installed on-orbit can be mated/demated using only one hand, which does not preclude the use of either hand.

NOTE: Demonstration shall be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.4.4.12

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-030	MECHANICAL - CONTROLS SPACING DESIGN	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.4.1 Controls Spacing Design Requirements (I)
3.10.4.3 Noninterference (I)
3.10.4.4 Barrier Guards (I)

Requirement Summary:

Controls, barrier guards, and other protection devices must comply with minimum spacing requirements.

Detailed Descriptions of Requirements:

A. All spacing between controls and adjacent obstructions shall meet the minimum requirements provided in accordance with MSFC-RQMT-2888, Paragraph 3.10.4.1 for ungloved operation. Verification shall be considered successful when an inspection shows that the spacing between controls and adjacent obstructions is as specified.

B. Payloads shall provide protection devices that do not cover or obscure other displays or controls. (MSFC-RQMT-2888, Paragraph 3.10.4.3) Verification shall be considered successful when an inspection shows that protection devices do not cover or obscure other displays and controls.

C. Barrier guard spacing shall adhere to the requirements for toggle switches, rotary switches, and thumbwheels as specified in MSFC-RQMT-2888, Paragraph 3.10.4.4 for ungloved operation. Verification shall be considered successful when an inspection shows that the barrier guard spacing is as specified.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.5.1, 3.12.5.2.2, and 3.12.5.2.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-031	MECHANICAL - ACCIDENTAL ACTUATION PROTECTION	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.4.2 Protective Methods (I)
3.10.4.5 Recessed Switch Protection (I)
3.10.4.7 Hidden Controls (I)
3.10.4.8 Hand Controllers (I)

Requirement Summary:

These requirements protect against accidental actuation of switches or other control devices.

Detailed Descriptions of Requirements:

A. Payloads shall provide protection for controls to prevent accidental actuation including displays and controls used for maintenance and adjustment which could disrupt nominal operations if actuated. Suggested protective methods/requirements are in accordance with MSFC-RQMT-2888, Paragraph 3.10.4.2. Verification shall be considered successful when an inspection shows that the spacing between controls and adjacent obstructions is as specified.

B. When a barrier guard is not used to prevent accidental actuation, rotary switches that control functions shall be recessed as specified in MSFC-RQMT-2888, Paragraph 3.10.4.5. Verification shall be considered successful when an inspection shows that rotary switches that control critical functions, and do not have barrier guards, are addressed as specified.

C. Controls that cannot be directly viewed will be avoided. If present, hidden controls shall be guarded to prevent inadvertent actuation in accordance with MSFC-RQMT-2888, Paragraph 3.10.4.7. Verification shall be considered successful when an inspection shows that hidden controls are guarded to protect against inadvertent actuation.

D. Hand Controllers shall have a separate on/off control to prevent inadvertent actuation when the controller is not in use as specified in MSFC-RQMT-2888, Paragraph 3.10.4.8. Verification shall be considered successful when an inspection shows that hand controllers have a separate on/off control.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.5.2.1, 3.12.5.2.5, 3.12.5.2.8, and 3.12.5.2.9

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-032	MECHANICAL - POSITION INDICATION	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.4.6 Position Indication (I)

Requirement Summary:

The position of switches or other control devices should be evident without requiring removal of protective covers.

Detailed Descriptions of Requirements:

When switch protective covers are used, control positions shall be evident without requiring cover removal. Verification shall be considered successful when an inspection shows that the control position is evident without removal of the protective cover.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.5.2.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-033	MECHANICAL - VALVE CONTROLS	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.4.9.a Valve Controls (I)
3.10.4.9.b Valve Controls (I)
3.10.4.9.c Valve Controls (I)
3.10.4.9.d Valve Controls (I)
3.10.4.9.e Valve Controls (I)

Requirement Summary:

Valve controls need different types of handles, depending on the amount of torque needed to operate them. Rotary valves should be threaded such that they open in the counter-clockwise direction, and the handles should be sized for easy manipulation.

Detailed Descriptions of Requirements:

A. Low-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the investigation flight hardware drawings of valves classified as low-torque (i.e., requiring 1N-M (10 in-lb.) or less for operation) are equipped with a central pivot type handle.

B. Intermediate-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the investigation flight hardware drawings of valves classified as intermediate-torque (i.e., requiring between 1 and 2 N-M (10 and 20 in-lbs) for operation) are equipped with a central pivot or lever type handle.

C. High-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the investigation flight hardware drawings of valves classified as high-torque (i.e., requiring between 2 N-M (20 in-lbs) or more for operation) are equipped with lever-type handles.

D. Valve handle dimensions shall meet the requirements as specified in MSFC-RQMT-2888, Paragraph 3.10.4.9.d. Verification shall be considered successful when an inspection of the payload flight hardware drawings shows that valve handle dimensions meet the requirements.

E. Rotary valve controls shall be verified by inspection. Verification shall be considered successful when an inspection shows that rotary valve controls open the valve with a counter-clockwise motion.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.5.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-034	MECHANICAL - TOGGLE SWITCH DIMENSIONS	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.4.10 Toggle Switches (I)

Requirement Summary:

Toggle switches should be of a standard size.

Detailed Descriptions of Requirements:

Toggle switches shall be verified by inspection. Verification shall be considered successful when an inspection of the flight article drawings shows that toggle switch dimensions meet the requirements as specified in MSFC-RQMT-2888 Paragraph 3.10.4.10.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.5.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-036	MECHANICAL - CAPTIVE PARTS	ISS	A&D&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.5.1.a Stowage Container Contents Restraints (A&I)
3.10.5.1.b Stowage Container Contents Restraints (D)
3.10.5.1.c Stowage Container Contents Restraints (D)
3.10.5.3 Captive Parts (I)

Requirement Summary:

These requirements ensure that the contents of container/stowage box do not escape when they are opened; and they can be removed from the tray without using any tools. Also, any unrestrained parts that are temporarily removed from the containers/stowage box must be held captive.

Detailed Descriptions of Requirements:

A. i. The investigation container/stowage box contents restraints shall be verified by inspection and analysis. The inspection and analysis shall be of the drawings of the flight hardware or hardware which replicates the flight hardware configuration. Verification shall be considered successful when the inspection and analysis shows that all items in a container/stowage box are restrained in a manner to prevent floating when opened or closed.

ii. The investigation container/stowage box contents will be verified by demonstration. The demonstration shall be performed on the investigation container/stowage box contents or hardware. Verification shall be considered successful when a demonstration shows that the restrained investigation container/stowage box contents (including the restraints mentioned in 3.10.5.1.a) do not jam the drawer during opening or closing.

iii. The restraints for the investigation container/stowage box contents shall be verified by demonstration. The demonstration shall be performed on the investigation container/stowage box contents and the restraint. The verification shall be considered successful when the demonstration shows that the contents of the investigation container/stowage box can be removed and/or replaced without using a tool under 1 G.

B. Captive parts shall be verified by inspection. Verification shall be considered successful when the inspection shows that all parts that are removed on-orbit are held captive, or provisions for temporarily stowing the loose items are provided.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.6.1 and 3.12.6.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-037	MECHANICAL - HANDLES	ISS	A&D&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.10.5.4 Handles and Restraints (D or I)
3.10.5.5 Handle Location/Front Access (I)
3.10.6 Handle Dimensions (D)

Requirement Summary:
These requirements ensure that the investigation provide handles or other suitable means for grasping them (if required) and that the handles/grasping means satisfy specified design requirements.

Detailed Descriptions of Requirements:

A. All investigation items larger than 1ft^3 shall be provided with handles or other suitable means for grasping, tethering, carrying, and restraining as specified in MSFC-RQMT-2888 Paragraph 3.10.5.4. Verification of investigation equipment grasp capability shall be by demonstration or inspection. The demonstration shall be considered successful when it is shown that the portable equipment can be grasped using one hand either by a handle or other suitable means. The inspection shall utilize drawings to verify that a handle or other suitable grasp area is provided for portable equipment, and the item is larger than 1ft^3.

B. Handles and grasp areas shall be placed on the accessible surface of a payload item consistent with the removal direction in accordance with MSFC-RQMT-2888 Paragraph 3.10.5.5. Verification shall be considered successful when an inspection of the flight hardware drawings confirms compliance with the requirement.

C. Hinged, foldout, or attachable (i.e., non-fixed) handles will comply with the requirements below:
Verification shall be considered successful when the following items are met:
   i. An analysis of flight hardware drawings and demonstration of the flight hardware confirms that non-fixed handles have a stop position for holding the handle perpendicular to the surface on which it is mounted.
   ii. Demonstration of flight hardware shows that non-fixed handles can be put in the use position by one hand and that they can be removed or stowed with one hand.
   iii. Inspection and demonstration of flight hardware confirms that attachable/removable handles incorporate tactile and/or visual indication of locked/unlocked status.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.6.4.1, 3.12.6.4.3, 3.12.6.4.4, and 3.12.6.4.5 and Table 3.12.6.4.2-1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-041	MECHANICAL - BAR CODING	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
C.3.5.11 Bar Coding (I)

Requirement Summary:

Loose equipment, consumables, and ORUs are required to have "code 39" bar codes for identification.

Detailed Descriptions of Requirements:

Bar coding shall be verified by inspection. Verification shall be considered successful when an inspection shows that decals, labels, or placards using bar codes are as specified in MSFC-RQMT-2888, Paragraph C.3.5.11 (Appendix C), and are identified on the drawings or on the flight equipment for loose equipment, consumables, and ORUs.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.7.5.13

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-043	MECHANICAL - LIGHTING DESIGN	ISS	D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.2.2.4 Lighting Design (D)

Requirement Summary:

Lighting provided by the investigation shall be dimmable.

Detailed Descriptions of Requirements:

A. Verification of a dimmable light source shall be by demonstration. The demonstration shall be considered successful when the light source is demonstrated to be continuously adjustable between 0 (off) and 100 percent (on) output.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.12.3.4 and Tables 3.12.3.4-1 and 4.3.12.3.4-1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-046	MECHANICAL - ATTACHMENT PROVISIONS	IIT	T&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.1.3 Attachment Provisions (T)

Requirement Summary:

The investigation attach points must be compatible with the MSG structural attach points.

Detailed Descriptions of Requirements:
The investigation shall participate in a physical and integrated interface verification test of the investigation hardware with MSG as specified in MSFC-RQMT-2888, paragraph 3.1.1.3.

Investigation provided fasteners shall be verified by inspection. Verification shall be considered successful when the inspection shows that the fasteners are M6x1.0 pitch with an engagement of 5mm to 10mm. Closed prior to testing with EU

Required Verification Data:	Data Submittal Dates:
1. Physical Test and exclusion zone test (using either EU or GU)	1. L-20
2. Integrated Test with EU	2. L-9
3. Inspection of fasteners (closed prior to testing with the EU)	3. L-9.5

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-053	MECHANICAL - BURRS AND PROTRUSIONS	ISS	A&I	

MSFC-RQMT-2888 Paragragh Number(s), Title(s), and Method(s):
3.10.8.4.4 Securing Pins (A)
3.10.8.4.5 Levers, Cranks, Hooks, & Controls (A&I)
3.10.8.4.6 Burrs (I)

Requirement Summary:

Burrs and catch points of investigation hardware must be removed/protected from equipment that is accessible to the crew.

Detailed Descriptions of Requirements:

A. Securing Pins
An analysis of payload hardware and flight drawings shall be performed to verify that securing pins above handholds do not back out. The verification shall be considered successful when the analysis shows the requirement has been met.

B. Levers, Cranks, Hooks, and Controls
Verification shall be by analysis and inspection. The verification shall be considered successful when the inspection and analysis shows that all levers, cranks, hooks, and controls have been properly covered or guarded, and cannot pinch, snag, or cut the crewmembers or their clothing.

C. Burrs
Verification shall be by inspection. The verification shall be considered successful when the inspection shows that all surfaces have been properly deburred.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 50005, par. 6.3.1.1
SSP 57000, par. 3.12.9.6, 3.12.9.7, and 3.12.9.8
NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-055	MECHANICAL - FIRE SUPPRESSION ACCESS HOLE	ISS	A&I&D	

MSFC-RQMT-2888 Paragragh Number(s), Title(s), and Method(s):
3.8.1.2a,b,c Investigation Fire Suppression

Requirement Summary:

FIRE SUPPRESSION ACCESS HOLES MUST BE PROVIDED; THEY MUST ALSO BE USABLE, AND LABELED.

Detailed Descriptions of Requirements:
A. Portable Fire Extinguisher
Verification that investigation hardware located outside the WV provides a Portable Fire Extinguisher (PFE) access port for equipment containing a potential fire source shall be by inspection and analysis. Verification shall be considered successful when the inspection of the hardware to flight approved drawing's shows that the access port is a hole between 12.7 mm (0.5 inch), for a panel thickness of < 3.175 mm (0.125 inch) and 25.4 mm (1.0 inch.) in diameter for a panel thickness of > 3.175 mm (0.125 inch).
B. Fire Suppression Access Port Accessibility
Verification that the design of the investigation permits the PFE nozzle to interface with the access port shall be by demonstration. Verification shall be considered successful when the demonstration shows that the design of the investigation allows the PFE nozzle to interface with the access port.
C. Labeling
Verification that the PFE access port is labeled with a SDD 32100397-002 “Fire Hole Decal” shall be by inspection. Verification shall be considered successful when the inspection shows that a SDD 32100397-002 “Fire Hole Decal” has been placed over the PFE access port.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
FED-STD-595
MSFC-STD-275
SSP 57000, par. 3.1.1.4, 3.10.3.1, 3.10.3.2, 3.10.3.3, and 3.10.4 and Figure 3.1.1.3
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-ME-057	MECHANICAL –IDENTIFICATION LABELING	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.7 Identification Labeling (I)

Requirement Summary:
This requirement ensures that labels required for investigation hardware are designed and developed in accordance with the requirements specified in MSFC-RQMT-2888 Appendix C.

Detailed Descriptions of Requirements:
An inspection shall be performed on all Labels on investigation hardware, loose equipment, consumables, ORUs, crew accessible connectors and cables, switches, indicators, and controls. The inspection shall be of the ISS Payload Label Approval Team (IPLAT), approval documentation provided in accordance with MSFC-RQMT-2888 Appendix C. The verification shall be considered successful when all of the above items have been shown to have IPLAT approved labels.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) showing IPLAT approval.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.12.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-001	ELECTRICAL - STEADY-STATE VOLTAGE CHARACTERISTICS	ISS&IIT	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.1.1 Steady State Voltage Characterisitcs (T)

Requirement Summary:

Investigation power must be compatible with the nominal RPDA voltage range.

Detailed Descriptions of Requirements:

The investigation shall be operated under selected loading conditions that envelope the operational loading. In general it will be sufficient to show that the hardware performs in various load conditions at the low voltage limit and at the high voltage limit. The verification shall be considered successful when the test data shows that the investigation can perform all functional capabilities under low and high voltage conditions and that EPCE is compatible with the steady-state voltage limits as specified in MSFC-RQMT-2888, Table III.

Note: Closed prior to testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Test report (prior to testing with the EU)	1. L-9.5

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.1.1.1 and 3.2.1.1.2

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-002	ELECTRICAL - RIPPLE VOLTAGE CHARACTERISTICS, NOISE, AND SPECTRUM	ISS&IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.1.2.1 Ripple Voltage and Noise (A)
3.2.1.2.2 Ripple Voltage Spectrum (A)

Requirement Summary:

These requirements ensure that all investigation or other electrical-power-consuming equipment are compatible with specific ripple voltage, ripple-voltage spectrum, and ripple-voltage noise characteristics of the RPDA.

Detailed Descriptions of Requirements:

Ripple Voltage and Noise requirements shall be verified by analysis.
The verification shall be considered successful when the analysis of the CS-01 test data (see MSFC-RQMT-2888, Appendix B, B.2.2.1 and subs) shows that the investigation EPCE connected to the RPDA operates and is compatible with the RPDA ripple voltages and noise levels at the frequencies specified in MSFC-RQMT-2888, Table IV.

Ripple Voltage Spectrum requirements shall be verified by analysis.
The verification shall be considered successful when the analysis of the CS-01 and CS-02 test data (see MSFC-RQMT-2888, Appendix B, B.2.2.1 and subs, and B.2.2.2 and subs) shows that the investigation EPCE connected to the RPDA operates and is compatible with the EPS Ripple Voltage Spectrum shown in MSFC-RQMT-2888, Figure 8.

Required Verification Data:	Data Submittal Dates:
1. Analysis providing plot of input voltage vs. frequency.	1. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 30237
SSP 30238
SSP 57000, par. 3.2.1.2.1, 3.2.1.2.2, 3.2.2.1, 3.2.2.2, 3.2.2.4, and Figure 3.2.1.2.2-1
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-003	ELECTRICAL - TRANSIENT VOLTAGES	ISS	A or T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.1.3 Transient Voltages (A or T)

Requirement Summary:

Investigation EPCE must be compatible with voltage transients on the electrical power system.

Detailed Descriptions of Requirements:

Input voltages shall be 116 Vdc and 126 Vdc.

Verification of compatibility with the specified Transient Voltages shall be performed by test or analysis of investigation EPCE operation across the transient envelope as specified in MSFC-RQMT-2888, Figure 9.

The verification shall be considered successful when the test or analysis shows that the EPCE is compatible with the transient voltage characteristics as specified in MSFC-RQMT-2888, Figure 9.

Note: It is sufficient to test at the high voltage and at the low voltage limit as specified in MSFC-RQMT-2888, Figure 9. (It is not necessary to test for 143.1 V transients from 116 V or for 99 V transients from 126 V.)

Required Verification Data:	Data Submittal Dates:
1. Test report or analysis showing compatibility with transients.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.1.3.1; Figure 3.2.1.3.1-1
SSP 30482, Vol. I

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-004	ELECTRICAL - FAULT CLEARING AND PROTECTION	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.1.3.1.a Fault Clearing and Protection (A)
3.2.1.3.1.b Fault Clearing and Protection (A)

Requirement Summary:

The investigation EPCE must be compatible with short-duration high voltage transients that can result from fault clearing and protection system operation.

Detailed Descriptions of Requirements:

A. For investigation EPCE connected to the 120 Vdc power supply, Transient Voltages shall be as specified in MSFC-RQMT-2888, Figure 10 for both a worst-case positive and negative transient.
The verification shall be considered successful when analysis shows that the investigation EPCE does not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware from the EPS transient voltages as specified in MSFC-RQMT-2888, Figure 10.
Note: The transient shown in the expanded view is a composite of three possible transient conditions; consequently, the analysis may consist of separate examination of the 12 microsecond transient, the 150 microsecond transient and the 300 microsecond transient.

B. For investigation EPCE connected to the 28 Vdc secondary power source, transient voltages shall be as specified in MSFC-RQMT-2888, Figure 11.
The verification shall be considered successful when analysis shows that the investigation EPCE does not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware from the EPS transient voltages as specified in MSFC-RQMT-2888, Figure 11.

Required Verification Data:	Data Submittal Dates:
1. Analysis showing compliance.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.1.3.3 and Figure 3.2.1.3.3-1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-005	ELECTRICAL - NON-NORMAL VOLTAGE RANGE	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.1.3.2 Non-normal Voltage Range (A)

Requirement Summary:

The Investigation EPCE must not produce an unsafe condition or one that could result in damage to ISS, MSG, or investigation equipment when non-normal voltages occur.

Detailed Descriptions of Requirements:

Verification of compatibility with Non-Normal voltage range conditions shall be performed by analysis. The analysis shall ensure that the investigation EPCE will not produce an unsafe condition nor a condition that could result in damage to ISS, MSG, or investigation equipment external to the investigation EPCE, when non-normal voltage levels as specified in MSFC-RQMT-2888, paragraph 3.2.1.3.2 are present. The analysis should be performed with all converters directly downstream of the RPDA.

The verification shall be considered successful when analysis shows that the investigation EPCE is safe within interface conditions as specified in MSFC-RQMT-2888, paragraph 3.2.1.3.2.

Required Verification Data:	Data Submittal Dates:
1. Analysis showing compliance.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.1.3.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-006	ELECTRICAL – POWER CHARACTERISTICS	IIT	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.1.a Electrical Power Characteristics (T)
3.2.1.b Electrical Power Characteristics (A)

Requirement Summary:
The total investigation power consumption must not exceed allowable limits defined in the Unique Investigation Hardware ICD.

Detailed Descriptions of Requirements:

Verification of investigation power consumption shall be accomplished by test. The total investigation power consumption shall not exceed the power allocation in the Unique Investigation Hardware ICD. The test shall be considered successful when test data confirms that the power allocation in the Unique Investigation Hardware ICD is not exceeded. This test shall be closed prior to testing with the EU.

An analysis shall be performed to show that the investigation hardware is compatible with the RPDA characteristics. The analysis shall be considered successful when compliance with MSFC-RQMT-2888, paragraph 3.2.1.b is met. This analysis shall be closed prior to testing with the EU.

Power draw measurements shall be taken for all investigations during the integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Power draw test report (showing power draw values prior to testing).	1. L-9.5
2. Analysis report (showing compatibility prior to testing).	2. L-9.5

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-007	ELECTRICAL - POWER AND C&DH CONNECTORS AND PIN ASSIGNMENTS	IIT	D&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.2.1.b,c,d Primary Power Connector (D&I)
3.2.2.2.b,c,d Secondary Power Connector (D&I)
3.10.3.3.11 Pin Identification (I)

Requirement Summary:

These requirements ensure that the connectors and pin assignments of the investigation and electrical-power-consuming equipment are compatible with the available interfaces.

Detailed Descriptions of Requirements:

A. Verification of primary and secondary power of the investigation physical mating to the WV connectors shall be by demonstration. The verification shall be considered successful when the demonstration shows that all investigation power interfaces identified in the Unique Investigation ICD can physically mate with the corresponding connectors.

Note: Demonstration will be done with the EU.

B. Verification of primary and secondary power connectors appropriate pin assignments shall be by inspection. The inspection shall be an inspection of the payload drawings to verify that the primary and secondary power connector pinouts are as specified in the Unique Investigation ICD. Closed prior to testing with the EU.

C. Pin identification shall be verified by inspection. Verification shall be considered successful when an inspection shows each pin is uniquely identified (i.e., labeled, every 10^{th} pin must be labeled), or requirements for pin identification are met as specified in paragraph 3.10.3.3.11. Closed prior to testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC). (COC for B & C prior to testing with EU)	1. L-9.5

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-010	ELECTRICAL - SURGE CURRENT	ISS&IIT	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.2.3.a Surge Current (A&T)
3.2.2.3.b Surge Current (A&T)

Requirement Summary:

The Investigation EPCE surge currents upon activation and deactivation must not exceed the allowable limits.

Detailed Descriptions of Requirements:

Verification of compatibility with Surge Current limits shall be performed by test at high, nominal, and low input voltage values as specified. Input power to the investigation EPCE should be representative of the ISS power environment. The power source used to perform the test shall be capable of providing a range of power between 0 kW to 6 kW at 116-126 Vdc. The EPCE shall be operated under worst-case loading conditions that envelope operational loading and voltage ranges. The analysis shall be performed using test data from the above test. The analysis shall show that the EPCE surge current envelope does not exceed the limits as specified in MSFC-RQMT-2888, paragraph 3.2.2.3. a and b. These requirements apply to all operating modes and changes including power-up and power-down.

Surge current measurements shall be taken for all investigations during the integrated testing with the EU..

Required Verification Data:	Data Submittal Dates:
1. Analysis report including surge current profiles for integrated investigation configuration.	1. L-9.5
2. Test report.	2. L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.2.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-011	ELECTRICAL - REVERSE CURRENT	ISS&IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.2.4.1 Reverse Current Limits (A)
3.2.2.4.2 Transients Partially Contained Within the Envelope (A)

Requirement Summary:

The equipment must not introduce unacceptable Reverse Current into the ISS power system.

Detailed Descriptions of Requirements:

Verification of compatibility with Reverse Current limits shall be performed by analysis at 3 kW.
If the investigation connected to the 120 VDC interface has an aggregate input connected capacitance of less than 25 micro–farads, no verification is required.
Input power to the EPCE should be representative of the ISS power environment.

Verification of compatibility with reverse current limits shall be performed by analysis. The input voltages prior to the occurence of fault shall be 116V and 126V for EPCE connected to the 120 VDC interface. The EPCE shall be analyzed under selected loading conditions that envelope operational loading. The verification will be considered successful when analysis shows that the EPCE connected to the 120 VDC interface complies with requirements defined in paragraphs 3.2.2.4.1 for the reverse current.

If the integrated rack or EPCE meets the requirements in paragraph 3.2.2.4.1, no verification is required for 3.2.2.4.2.

If the reverse current exceeds the envelope limits defined in paragraph 3.2.2.4.1 for one or more short time intervals, the requirement for reverse current transients partially contained within the envelope shall be verified by analysis.
The verification will be considered successful when analysis shows that the EPCE connected to the 120 VDC interface complies with the requirement defined in paragraph 3.2.2.4.2 for the reverse current exceeding the envelope limits defined in paragraph 3.2.2.4.1 for one or more short time intervals.

Required Verification Data:	Data Submittal Dates:
1. Analysis shows that the EPCE complies with requirements defined in paragraph 3.2.2.4.1 for the reverse current into the upstream power source. If required: 2. Analysis shows that the EPCE complies with requirement defined in paragraph 3.2.2.4.2 for the reverse current exceeding the envelope limits defined in paragraph 3.2.2.4.1 for one or more short time intervals.	1. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.2.5 and Figures 3.2.2.5-1, 3.2.2.5-2, 3.2.2.5-3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-012	ELECTRICAL – CIRCUIT PROTECTION DEVICES	IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.2.5.a Circuit Protection Devices (A)
3.2.2.5.b Circuit Protection Devices (A)
3.2.2.5.c Circuit Protection Devices (A)
3.2.2.5.d Circuit Protection Devices (A)

Requirement Summary:
Investigation hardware connected to the MSG RPDA must be compatible with the power outlet trip characteristics.

Detailed Descriptions of Requirements:

An analysis shall be performed to show that the investigation hardware connected to the RPDA is compatible with the power outlet trip characteristics.

For the 120 Vdc primary power source, the analysis shall be considered successful when the analysis shows compliance with MSFC-RQMT-2888, paragraph 3.2.2.5.a and Figure 19.

For the 28 Vdc secondary power source, the analysis shall be considered successful when the analysis shows compliance with MSFC-RQMT-2888, paragraph 3.2.2.5.b and Figure 20.

For the 5 Vdc secondary power source, the analysis shall be considered successful when the analysis shows compliance with MSFC-RQMT-2888, paragraph 3.2.2.5.c.

For the ±12 Vdc secondary power source, the analysis shall be considered successful when the analysis shows compliance with MSFC-RQMT-2888, paragraph 3.2.2.5.d.

Required Verification Data:	Data Submittal Dates:
1. Analysis report.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-013	ELECTRICAL - OVERLOAD PROTECTION	ISS	A,D&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.8.3.1 Device Accessibility (I) 3.10.8.3.4 Overload Protection Identification (I)
3.10.8.3.2 Extractor-Type Fuse Holder (D) 3.10.8.3.5 Automatic Restart Protection (A)
3.10.8.3.3 Overload Protection Location (I)

Requirement Summary:
Investigation hardware must meet overload protection accessibility, location, labeling, and identification specifications.

Detailed Descriptions of Requirements:

A. Investigation hardware inspection shall be used to verify that an overload protective device will not be accessible without opening a door or cover (except operating handles or buttons of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts that project outside the enclosure). Verification shall be considered successful when inspection of the Investigation hardware to the drawing's shows that a door or cover must be opened to access the overload protective device.

B. Demonstration shall be used to verify that the arrangement of the extractor-type fuse holder operates such that the fuse is extracted when the cap is removed. Verification shall be considered successful when demonstration shows that the fuse is extracted when the removable cap assembly is removed.

C. Investigation hardware inspection shall be used to verify that overload protection (fuses and circuit breakers), intended to be manually replaced or physically reset on-orbit, are located where they can be seen and replaced or reset without removing other components. Verification shall be considered successful when Investigation hardware inspection results show that overload protection devices are directly visible and accessible without removal of other components.

D. Investigation hardware inspection shall be used to verify that each overload protector (fuse or circuit breaker), intended to be manually replaced or physically reset on-orbit, shall be readily identified or keyed (mechanically or color coded) for its rated value. Verification shall be considered successful when inspection results shows that the rated identification for each overload protector is in place.

E. Investigation shall assure that Automatic Restart does not occur unless the Protection Switch/Control is explicitly operated to enable restarting. The verification of Automatic Restart Protection shall be considered successful when an analysis shows that automatic restart cannot occur following an overload-initiated shutdown without explicit operation of the protection switch/control to enable restarting.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.2.2.6.1.1, 3.12.9.1.4.1, 3.12.9.1.4.2, 3.12.9.1.4.3, 3.12.9.1.4.4, and 3.12.9.1.4.5

Number	Title	Method	Hazard Report(s)
ITT-EL-014	ELECTRICAL - COMPLEX LOAD IMPEDANCE	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.2.7 Investigation Complex Load Impedance (T)

Requirement Summary:

Investigation load impedance must meet the amplitude and phase requirements.

Detailed Descriptions of Requirements:

Investigation load impedance shall meet the amplitude and phase requirements as specified in MSFC-RQMT-2888, paragraphs 3.2.2.7. If downstream devices can be shown to have negligible effect on load impedance magnitude and phase, or be realistically simulated by passive devices, then simulated loads may be used as downstream devices for test. Load impedance shall be tested under conditions of high, nominal, and low voltage, this will be tested using the EU rack. The active converters directly downstream shall also be exercised through the complete range of their loading. Selected combinations of converters that can influence the measured load impedance at the interface shall be tested.

The verification shall be considered successful when the test shows that all load impedances measured for high, nominal and low voltage conditions remain within specified limits.

Note: The test report shall include the following:

1. A brief description of the test setup and procedure.
2. Input impedances for each configuration tested, magnitude and phase between 100 Hz and 100 kHz, with a minimum of 20 points per decade being measured.
3. An electronic copy of data and figures via floppy disc or other agreed electronic media.

Format:

1. Graphical Data - plots of magnitude and phase versus frequency on a log scale. Identify with each plot:
   A. The combination of RPCs and switches that are powered (closed)
   B. Which electrical items are “on”, including items which have filters powered when the EPCE is “off”.
   C. The operational state or mode of each powered EPCE.
2. Tabular Data: Space or tab-delimited ASCII data, one row per frequency point, terminated in a carriage return/line feed, or in EXCEL file format.

The EU shall be used with the PRCU when performing this test. Impedance measurements shall be taken for all investigations during the integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Test Report showing compliance with the amplitude and phase requirements.	1. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.2.7.1 and 3.2.2.7.2

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-015	ELECTRICAL - MAXIMUM RIPPLE VOLTAGE EMISSIONS	ISS	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.2.6 Deleted

Requirement Summary:

Investigation EPCE induced Ripple Voltage emissions must not exceed allowable limits.

Detailed Descriptions of Requirements:

Deleted

Required Verification Data:	Data Submittal Dates:
1.	1.

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-016	ELECTRICAL – LOAD-STAND ALONE STABILITY	IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.2.9 Electrical Load-Stand Alone Stability

Requirement Summary:
Load stability must be maintained under all nominal source/load conditions.

Detailed Descriptions of Requirements:
Load stability shall be verified by analysis of test data for CS-01, CS-02, and CS-06 (See VDS EL-020 for test requirements).. The verification shall be considered successful when analysis of test data from the requirements identified in the following paragraphs are met.: (CS01) paragraph 3.2.4.4.2.2.1, (CS02) paragraph 3.2.4.4.2.2.2, and (CS06) paragraph 3.2.4.4.2.2.3.

NOTE: WAIVERS TO EMI DO NOT CONSITUTE A WAIVER TO THIS REQUIREMENT.

Required Verification Data:	Data Submittal Dates:
1. Analysis report (A brief summary of the results of EMI/EMC tests). A detailed report independent of EMI/EMC request for waiver is necessary to show that stand-alone stability exists if EMI/EMC waivers or deviations are required).	1. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 30238
SSP 57000, par. 3.2.2.8 and 3.2.2.10

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-017	ELECTRICAL - WIRE DERATING	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.3.1 Wire Derating (A)

Requirement Summary:

Wires must be derated for location and temperature of operation, and downstream wires from a protective device must have the capability of carrying the full current load.

Detailed Descriptions of Requirements:

Analysis shall be based upon the requirements of JSC Technical Memorandum 102179 as interpreted by NSTS/ISS 18798, Letter TA-92-038. These requirements ensure that wires are derated for location and temperature of operation and that downstream wires from a protective device each have the capability of carrying the full current load permitted by the protective device.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

NSTS/ISS 18798, Tech-memo 102179
SSP 30312
SSP 57000, par. 3.2.3.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-020	ELECTRICAL - ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY	ISS	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.4 Electromagnetic Compatibility (A & T)
3.2.4.4 Electromagnetic Emission and Susceptibility (A & T)
3.2.4.6 Alternating Current (ac) Magnetic Fields (A or T)
3.2.4.7 Direct Current (dc) Magnetic Fields (A & T)

Requirement Summary:
All investigation EPCE, must assure electromagnetic compatibility and protect against electromagnetic interference.

Detailed Descriptions of Requirements:

A. Electromagnetic Compatibility
The Electrical-EMC verification test requirements are met when results show that investigation EPCE EMC is in compliance with the requirements of MSFC-RQMT-2888, section 3.2.4 and subs. The analysis is based on end item qualification and EPCE design and analysis data. The analysis requirements are met when the data shows the investigation EPCE meets the EMC requirements of MSFC-RQMT-2888, section 3.2.4 and subs.

B. Electromagnetic Interference (Emission and Susceptibility Requirements)
Electromagnetic Interference (EMI) requirements for the investigation EPCE are considered met when all EMI test requirements of MSFC-RQMT-2888 are met. Test methods are specified in Appendix B of MSFC-RQMT-2888. The test requirements for the investigation EPCE are met when results show that the requirements of MSFC-RQMT-2888, section 3.2.4.4 and subs are met. The analysis of investigation EPCE is performed using subrack payload test data. The analysis shall be based on end item qualification data and investigation EPCE design and analysis data. The analysis shall be considered successful when the data shows the integrated rack and EPCE meet the EMC requirements of MSFC-RQMT-2888, section 3.2.4.4 and subs. An isolation evaluation must be included in the EMI analysis to verify the requirements of MSFC-RQMT-2888, section 3.2.4.4 and subs are met.

C. Alternating Current (ac) Magnetic Fields
Verification of the ac magnetic field emissions (30 Hz to 50 kHz), for investigation EPCE, shall be by test or analysis of equipment, cables, and interconnecting wiring. The analysis should be based on the test data of the components which generate the magnetic fields. Test setup guidelines will be per MSFC-RQMT-2888, Figure 47 or 48, not the setup identified by MIL-STD-462D. Guidelines of MSFC-RQMT-2888, Figure 47 and 48, requirement of 1 meter separation does not apply to RE01. Measurements are required from 30 Hz to 50 kHz rather than 100kHz required by MIL-STD-461D. Measurements are performed at 7cm from the generating equipment. In the event emissions are out-of-specification, measurements are performed at 50 cm from the generating equipment. Documentation may be included under 3.2.4.4 above. Verification shall be considered successful when test results show the generated ac magnetic fields of the investigation EPCE, including cables and interconnecting wiring, do not exceed the magnetic fieldsemission limits of 140 dB above 1 picotesla for frequency at 30Hz, and then falling 26.5 dB per decade to 3.5 kHz and 85 dB for frequencies ranging from 3.5 kHz to 50 kHz..

D. Direct Current (dc) Magnetic Fields
For equipment containing electromagnetic or permanent magnetic devices, verification that the equipment meets dc magnetic field emissions requirement of 170 dBpT shall be by test and analysis. The measurement or analysis of dc magnetic fields will be performed at 7 cm from the enclosure of the generating equipment. Measurements or analysis at 10 cm from the generating equipment will be performed if there is a dc magnetic field greater than 170 dBpT. Additional measurements or analysis will be performed at 10 cm increments away from the generating equipment until data proves the dc magnetic fields are 6 dB below the 170 dBpT. The verification will be considered successful when test or analysis results show the generated dc magnetic fields of the investigation EPCE connected to the RPDA do not exceed 170 dBpT at a distance of 7 cm from the generating equipment, including electromagnetic and permanent magnetic devices. Documentation may be included under 3.2.4.4 above. Verification closure will be accomplished under this paragraph number.

continued on next page

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-020	ELECTRICAL - ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY	ISS	A&T	

continued from previous page

Required Verification Data:	Data Submittal Dates:
1. Test Report for Item A (Results must be provided for each configuration in the worst-case operational modes. The report should include the test configuration/layout (including cables), photographs of the test configuration, and a description of testing equipment.)	1. L-10
2. Test results in electronic format for Item A and B.	2. L-10
3. For requirement 3.2.4.7, item D above, a tabular listing of each magnetic field measurement, distance from Equipment Under Test (EUT), and mode of EUT operation.	3. L-10
4. For item C above, emissions greater than 20 dB below specified limits will be recorded in the EMI test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded. (This verification data is submitted as part of Item 2 above, if required.)	4. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MIL-STD-461
SSP 30237 (Entire Document)
SSP 30238 (Entire Document)
SSP 30243, par. 3.1, 3.5 and 3.6.2
SSP 57000, par. 3.1.1.4.G, 3.2.4, 3.2.4.4, 3.2.4.6, and 3.2.4.7
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-021	ELECTRICAL - CABLE/WIRE DESIGN AND GROUNDING	ISS	A&T or A&T&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.4.1 Electrical Grounding (A&T)
3.2.4.3 Cable/Wire Design and Control Requirements (A&T&I)

Requirement Summary:

Equipment must be electrically grounded and cable/wire design requirements must be met.

Detailed Descriptions of Requirements:

A. Electrical Grounding
The test will be considered successful when the results show that the investigation EPCE connected to the RPDA is in compliance with the requirements in Section 3.2.4.1 and subs of MSFC-RQMT-2888.
The analysis will be based on end item qualification data and EPCE design and analysis data. The analysis will be considered successful when the data shows the investigation EPCE connected to the RPDA is electrically grounded within the requirements of Section 3.2.4.1 and subs of MSFC-RQMT-2888 with shall statements. Closed prior to testing with EU.

B. Cable/Wire Design and Control Requirements (External Cables)
The test will be considered successful when the results show all requirements of Section 3.2.4.3 and subs of MSFC-RQMT-2888 with shall statements are met.
The analysis will be based on end item qualification data and EPCE design and analysis data. The analysis will be considered successful when the results show all the requirements of Section 3.2.4.3 and subs of MSFC-RQMT-2888 with shall statements are met.
The inspection will be based on physical/visual indications of the EPCE connected to the RPDA. The inspection will be considered successful when physical/visual indications show that external cable and wire design is in compliance with the requirements of Section 3.2.4.3 and subs of MSFC-RQMT-2888 with shall statements are met.

Harness requirements can normally be met by inspection of drawings and hardware.

Analysis is required to classify signals and determine the necessary isolation between signals.

Test may be required to determine impedance and sensitivity characteristics of the circuit when classification cannot be determined by examination of the circuit known characteristics.

Required Verification Data:	Data Submittal Dates:
1. Analysis report showing compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report) closed prior to testing with EU, and the compliance with Section 3.2.4.3 and subs of MSFC-RQMT-2888 with shall statements.	1. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 30240, Sec. 3
SSP 30243
SSP 57000, par. 3.2.4.1 and 3.2.4.3
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-022	ELECTRICAL - BONDING	ISS	A&I&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.4.2 Electrical Bonding (A&I&T)

Requirement Summary:

Equipment must be electrically bonded.

Detailed Descriptions of Requirements:

The test will be considered successful when the results show all requirements of Section 3.2.4.2 and subs of MSFC-RQMT-2888 are met.

The analysis will be based on end item qualification data and investigation EPCE design and analysis data. The analysis will be considered successful when the data shows the investigation EPCE is electrically bonded within the requirements of Section 3.2.4.2 and subs of MSFC-RQMT-2888 are met. The inspection will be based on physical/visual indications of the investigation EPCE. The inspection will be considered successful when physical/visual indications show all requirements of Section 3.2.4.2 and subs of MSFC-RQMT-2888 are met. (Inspection results should be included in the test or analysis report.)

NOTE: A bonding test shall be performed with the investigation hardware mounted in the MSG in its flight configuration. The bonding test shall be taken for all investigations during the integrated testing with the EU. Bonding requirement shall be considered successful when the test results show that the bond between the investigation and the EU is less than 1 ohm.

Required Verification Data:	Data Submittal Dates:
1. Test report showing compliance with Section 3.2.4.2 and subs of MSFC-RQMT-2888.	1. L-10
2. Analysis report showing compliance with Section 3.2.4.2 and subs of MSFC-RQMT-2888.	2. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

NSTS 1700.7 ISS Addendum, Sec. 213 and 220
SSP 30245, (Entire Document)
SSP 57000, par. 3.2.4.2

Number	Title	Method	Hazard Report(s)
ITT-EL-023	ELECTRICAL - LARGE SIGNAL STABILITY	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.2.8 Large Signal Stability (A&T)

Requirement Summary:

Transient responses to large signal disturbances are to diminish within specified time limits.

Detailed Descriptions of Requirements:

The purpose of this test is to verify stability when a large voltage disturbance, sufficient to cause current limiting in upstream protective devices, or other non-linear effects is present at input to the MSG rack and Investigation EPCE. The following report data is to be provided:

1. Test configuration detail showing which EPCE was active for each test configuration.
2. Description of prototype, substitute, or missing flight EPCE items.
3. Current and voltage profiles for the input pulse and response as specified in MSFC-RQMT-2888, paragraph 3.2.2.8.

It is necessary to show stability with the worst-case combination of loads that will be used. It will be necessary to develop payload EPCE models and to verify these models by the Large Signal Stability Test if on-orbit change of loads is foreseen, to avoid the requirement of performing stability tests on-orbit. Compatibility with other payload EPCE is not ensured by the time-to-dampen criterion, just compatibility with ISS. Consequently, detailed large signal response data may be required for integration, particularly in cases where payloads share significant source impedance.

This test requires use of a LISN with inductance and resistance set according to the load rating. TheMSG facility and investigation EPCE response is monitored for damping within a specified period of time rather than a minimum damping coefficient. The transient duration criterion is used to ensure that transient response, regardless of extent of damping returns to the steady-state voltage range of ISS EPS.

Large signal stability shall be verified by test and analysis. A large signal stability test shall be conducted with the investigation EPCE configured in the MSG EU during integrated testing. An integrated analysis shall be provided by the MSG IIT for representative maximum and minimum case loads to demonstrate that the impedance variations will not impact system stability. The input and transient response waveform for the MSG facility and investigation EPCE shall be recorded from the start of impulse through the time when the transient diminishes to, and remains below, 10% of the maximum amplitude of the response.

The test and analysis will be considered successful when results show transient responses, measured at the input to MSG facility oand investigation EPCE, diminish to 10% of the maximum amplitude within 1.0 milliseconds and remains below 10% thereafter.

The EU shall be used with the PRCU when performing this test. Stability measurements shall be taken for all investigations during the integrated testing with the EU

Required Verification Data:	Data Submittal Dates:
1. Preliminary analysis and test data for each integrated rack and EPCE.	1. L-10
2. Final analysis and test data for each integrated rack and EPCE.	2. L-8

Continued on next page

Number	Title	Method	Hazard Report(s)
ITT-EL-023	ELECTRICAL - LARGE SIGNAL STABILITY	A&T	

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details	T	

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.2.8 and Figures 3.2.2.8-1

D684-10572, Large Signal Stability Demonstration Test Report

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-024	ELECTRICAL - ELECTROSTATIC DISCHARGE	ISS	A&I or T&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.2.4.5 Electrostatic Discharge (A&I or I&T)

Requirement Summary:

Equipment must not be susceptible to electrostatic discharges of less than 15, 000 volts

Detailed Descriptions of Requirements:

Electrostatic Discharge (ESD) (Susceptibility to ESD)

The analysis will be based on investigation EPCE design and analysis data. The test or analysis will be considered successful when the results show the requirements in MSFC-RQMT-2888, paragraph 3.2.4.5 have been met.

Analysis of the investigation EPCE is normally accomplished by evaluating test data of the investigation EPCE input circuitry (in some instances this data can be in the form of manufacturing data).

The inspection will be based on physical/visual inspection of the investigation EPCE. The inspection will be considered successful when physical/visual indications show the labeling of investigation EPCE susceptible to ESD up to 15, 000 Volts are in accordance with MIL-STD-1686A. (Inspection results should be included in the test or analysis report.)

Required Verification Data:	Data Submittal Dates:
1. A report on test results or an analysis showing compliance with MSFC-RQMT-2888, paragraph 3.2.4.5.	1. L-10
2. Certificate of compliance (COC) showing that the inspection identifies labeling of the investigation EPCE.	2. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MIL-STD-1686
SSP 57000, par. 3.2.4.5
NSTS.1700.7
NSTS-21000-IDD-MDK

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-026	ELECTRICAL - ARC CONTAINMENT	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.3.6 Arc Containment (A)

Requirement Summary:
Electrical connector plugs must confine or isolate the electrical arcs or sparks associated with mating and demating.

Detailed Descriptions of Requirements:
Arc containment shall be verified by analysis. Verification shall be considered successful when an analysis of the flight hardware drawings shows that electrical connector plugs confine/isolate the mate/demate electrical arcs or sparks.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 57000, par. 3.12.4.3.7
NSTS 1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-029	ELECTRICAL - POWER SWITCHES/CONTROLS	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.2.5.3.a Power Switches/Controls (A)
3.2.5.3.b Power Switches/Controls (A)
3.2.5.3.c Power Switches/Controls (A)

Requirement Summary:
These requirements protect the ISS and its crew from accidents related to electrical shock. Power on/off switches/controllers must indicate when all electrical connections with the power supply are discontinued. If the power supply is not completely disconnected, then a crewmember should be able to determine this by examining the indicators. While in the power-off position, all power supply conductors (except the power return and grounding conductor) must be open (dead-faced).

Detailed Descriptions of Requirements:

a. Switches/controls requirements shall be verified by analysis. An analysis shall be performed to ensure that the switches/controls performing on/off functions for all power interfaces open (dead-face) all supply circuit conductors, except the power return and equipment grounding conductor, while in the power-off position. Verification shall be considered successful when analysis of electrical circuit schematics shows that the switches/controls performing on/off power functions, all power interfaces open (dead-face) all supply conductors except the power return and equipment grounding conductor, while in the power-off position.

b. Power-off markings and/or indications requirement shall be verified by analysis. The analysis shall ensure that power-off markings and/or indications exist when all electrical connections with the power supply circuit are disconnected. The verification shall be considered successful when analysis shows that power switches/controls power-off markings and/or indication(s) exist when all electrical connections with the power supply circuit are disconnected.

c. Standby, charging, and descriptive nomenclature requirement shall be verified by analysis. The analysis shall ensure the existence of descriptive nomenclature such as standby, charging, or whatever is necessary to indicate that the power supply circuit is not completely disconnected. The verification shall be considered successful when analysis shows descriptive nomenclature exists to indicate that the power supply circuit is not completely disconnected.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.5.3

NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-030	ELECTRICAL - GROUND FAULT CIRCUIT INTERRUPTERS	ISS	A&D&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
Deleted

Requirement Summary:

Deleted

Detailed Descriptions of Requirements:

Deleted

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.2.5.4 and table 3.2.5.4-1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-033	ELECTRICAL – RS422/ETHERNET CABLE CHARACTERISTICS	IIT	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
Deleted

Requirement Summary:

Medium-Rate Data Link (MRDL) cables must meet ISS requirements.

Detailed Descriptions of Requirements:

Deleted, requirement covered in C&DH section.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.3.6.1.6
SSQ 21655

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-037	ELECTRICAL – ICP OUTLET INTERFACE REQ.	IIT	D&I&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.7.2.3.1.a - f ICP Outlet Interface Requirements (D & I & T)

Requirement Summary:

The investigation spotlight/equipment connected to the ICP outlet must be compatible with MSG requirements.

Detailed Descriptions of Requirements:

A. Connector and Pin Assignments

i. Verification of the spotlight connector of the investigation physical mating to the MSG connector shall be by demonstration. The verification shall be considered successful when the demonstration shows that the investigation connectors can physically mate with the MSG connectors with the part number as specified in MSFC-RQMT-2888, Paragraph 3.7.2.3.1.a.

ii. Verification of appropriate pin assignment shall be by inspection. Inspection of payload drawings shall be used to verify that the P1 pinouts match the corresponding J1 pinouts. The verification shall be considered successful when the inspection shows that the P1 connector pinout is appropriate as specified in MSFC-RQMT-2888 Tables XXXI and XXXII.

B. Power Rating

Verification that the investigation spotlight/equipment does not exceed the power rating of 12V at 2 amps and that the max inrush current is not greater than 2 x nominal operating current for up to 10 ms shall be by test. The verification shall be considered successful when testing shows that the investigation complies with requirements defined in MSFC-RQMT-2888, Paragraph 3.7.2.3.1.c & d.

C. Other

Verification that the spotlight shall not be covered when on shall be by inspection. The verification shall be considered successful when inspection shows that the spotlight is not covered when on. Verification that the spotlight meets the bonding requirements in section 3.2.4.2 shall be considered successful when the required in EL-22 are met or an inspection and test that pin 24 provides a proper bonding path.

NOTE: The demonstration can be closed during physical or integrated testing using the EU. Testing the ICP interface power draw, bonding and inrush current shall be done during integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EL-041	ELECTRICAL – ELECTRICAL HAZARDS	ISS	A or T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

Deleted

Requirement Summary:

DELETED

Detailed Descriptions of Requirements:

Deleted

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP-5700, par. 3.12.9.1 and Table 3.2.5.4-1
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-01	C&DH – DIRECT EXPERIMENT INTERFACE HARDWARE REQUIREMENTS	IIT	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.3.1.1.1 Cable Characteristics (I) 3.3.1.1.2 Connector / Pin Assignments (I)
3.3.1.1.3 Signal Characteristics (I) 3.3.1.1.4 Port Settings (I)

Requirement Summary:

These requirements ensure that the investigation will correctly interface to the Direct Experiment Interface

Detailed Descriptions of Requirements:

Inspection of investigation hardware and documentation/drawings shall be performed to ensure:
1) Cable characteristics conform to section 3.3.1.1.1
2) Connectors and pin assignments conform to section 3.3.1.1.2
3) Components used to transmit and receive on the Direct Experiment Interface are RS422B compliant as stated in section 3.3.1.1.3
4) The RS422 port is configured to communicate at the settings defined in section 3.3.1.1.4.

Note: These verification items shall be closed prior to interface testing in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for inspection.	Prior to Integration testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

MSG-ORIGIN-IC-0001
MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-02	C&DH – DIRECT EXPERIMENT INTERFACE SOFTWARE REQUIREMENTS	IIT	T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):

3.3.1.2.1.1. Byte and Bit Order (T)
3.3.1.2.1.2. Word Alignment (T)
3.3.1.2.1.3 ESTEC Data Link Formant (EDLF) (T)
3.3.1.2.1.4 RC Required Headers (T)
3.3.1.2.2.1.1. Experiment Commands (T)
3.3.1.2.2.1.2 Time of Day (TOD) Data (T)
3.3.1.2.2.1.3 File Transfers (T), RC to WV
3.3.1.2.2.2.1 Command Acknowledges (T)
3.3.1.2.2.2.2. Experiment Health and Status (T)
3.3.1.2.2.2.3 Experiment Low Rate Telemetry (T)
3.3.1.2.2.2.4 File Transfers, WV to RC (T)
3.3.1.2.2.2.5 Log Messages (T)
3.3.1.2.2.2.6 MSG Video Commands (T)

REQUIREMENT SUMMARY:

These requirements ensure that the investigation can communicate with the Rack Controller through the Direct Experiment Interface.

Detailed Descriptions of Requirements:

Test verification of the investigation shall be performed using the MSG Engineering Unit to ensure communications with the RC are in accordance with sections 3.3.2.1.1 through 3.3.2.2.2.6.
Testing shall be considered successful when it can be shown that the Investigation hardware:
1) Responds correctly to all required messages transmitted from the PRCU
2) Successfully transmits all required messages to the PRCU.

Note: These tests shall be performed in the MSG Engineering unit with the PRCU.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSG-ORIGIN-IC-0001, MSFC-HDBK-3141, NSTS.1700.

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-03	C&DH – INVESTIGATION I/O INTERFACE HARDWARE REQUIREMENTS	IIT	I and T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):

3.3.2.1.1 Cable Characteristics (I) 3.3.2.1.2b Connector / Pin Assignments (I)
3.3.2.1.3 Signal Characteristics (T)

REQUIREMENT SUMMARY:

These requirements ensure that the Investigation will correctly interface to the Experiment Control Board through the Investigation I/O interface.

Detailed Descriptions of Requirements:

Inspection of investigation hardware and documentation/drawings shall be performed to ensure:
1) Cable characteristics conform to section 3.3.2.1.1
2) Connectors and pin assignments conform to section 3.3.2.1.2

Test of investigation hardware shall be performed to ensure:

1) Signal characteristics conform to section 3.3.2.1.3

Note: These verification items shall be closed prior to interface testing in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test. Certificate of Compliance (COC) for inspection.	Prior to Integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSG-ORIGIN-IC-0001
MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-04	C&DH – INVESTIGATION I/O INTERFACE SOFTWARE INTERFACE	IIT	T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):
3.3.2.2.2 Configuration and Control Commands (T)

REQUIREMENT SUMMARY:

This requirement ensures that uplink commands correctly configure and control the Investigation I/O interface to downlink Low Rate Telemetry data.

Detailed Descriptions of Requirements:

Test verification of Investigation I/O Interface Configuration and Control commands, shall be performed using the MSG flight unit to ensure Investigation I/O data is successfully transmitted to the PRCU.

Testing shall be considered successful when it can be shown that the Investigation data provided at the Investigation I/O Interface is successfully received at the PRCU.

Note: This test shall be performed in the MSG Engineering unit with the PRCU.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSG-ORIGIN-IC-0001
MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-05	C&DH – MLC SERIAL INTERFACE HARDWARE REQUIREMENTS	IIT	I	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):
3.3.3.1.1 Cable Characteristics (I)
3.3.3.1.2.1 MLC Outside the Work Volume (I)
3.3.3.1.2.2 MLC Inside the Work Volume (I)
3.3.3.1.3 Signal Characteristics (I)
3.3.3.1.4 Port Settings (I)

REQUIREMENT SUMMARY:

There requirements ensure that the investigation correctly Interfaces to the MSG Laptop Computer (MLC) through the MLC Serial Interface.

Detailed Descriptions of Requirements:

Inspection of investigation hardware and documentation shall be performed to ensure:

1) Cable characteristics conform to section 3.3.3.1.1

2) Connectors and pin assignments conform to section 3.3.3.1.2.1 for MLC locations outside the work volume OR

Connectors and pin assignments conform to section 3.3.3.1.2.2 for MLC locations inside the work volume:

3) Components used to transmit and receive on the MLC Serial Interface are RS232C compliant as stated in section 3.3.3.1.3.

4) Port settings conform to section 3.3.4.1.4

Note: These verification items shall be closed prior to interface testing in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for inspection.	Prior to Integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSFC-RQMT-3098, MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-06	C&DH – MLC SERIAL INTERFACE SOFTWARE REQUIREMENTS	IIT	T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):
3.3.3.2 Software Requirements (T)

REQUIREMENT SUMMARY:
This requirement insures that the Investigation can communicate with the MLC through the MLC Serial Interface and that the MLC is configured correctly to downlink data and receive commands where applicable.

Detailed Descriptions of Requirements:

Verification of MLC Serial Interface communications shall be by test using the MSG Engineering Unit, a Flight Equivalent MLC, and where appropriate the PRCU.

Testing shall be considered successful when it can be shown that:

1) Data to be transmitted from the Investigation to the MLC, is successfully transmitted by the Investigation and read by the MLC.

2) Data to be transmitted from the MLC to the Investigation, is successfully transmitted by the MLC and read by the Investigation.

3) Data to be transmitted from the Investigation to the ISS, is successfully transmitted by the Investigation and read by the PRCU.

4) Data to be transmitted from the ISS to the Investigation, is successfully transmitted by the PRCU and read by the Investigation.

Note: This test shall be performed in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSFC-RQMT-3098, MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-07	C&DH – MLC ETHERNET INTERFACE HARDWARE REQUIREMENTS	IIT	I	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):

3.3.4.1.1 Cable Characteristics (I) 3.3.4.1.2 Connector / Pin Assignments (I)
3.3.4.1.3 Signal Characteristics (I)

REQUIREMENT SUMMARY:

These requirements ensure that the Investigation can correctly interface to the MSG Laptop Computer (MLC) through the MLC Ethernet Interface.

Detailed Descriptions of Requirements:

Inspection of investigation hardware and documentation/drawings shall be performed to ensure:
1) Cable characteristics conform to section 3.3.4.1.1
2) Connectors and pin assignments conform to section 3.3.4.1.2
3) Components used to transmit and receive on the MLC Ethernet Interface are ISO/IEC 8802-3 compliant as stated in section 3.3.4.1.3
Note: These verification items shall be closed prior to interface testing in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for inspection.	Prior to Integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
ISO/IEC 8802-3
MSFC-RQMT-3098, MSFC-RQMT-2888

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-08	C&DH – MLC ETHERNET INTERFACE SOFTWARE REQUIREMENTS	IIT	T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):

3.3.4.2 Software Requirements (T)

REQUIREMENT SUMMARY:
This requirement ensures that the investigation can communicate with the MLC through the MLC Ethernet Interface and that the MLC is correctly configured to downlink and receive data when applicable.

Detailed Descriptions of Requirements:

Verification of the MLC Ethernet Interface shall be by test using the MSG Engineering Unit, a Flight Equivalent MLC, and where appropriate the PRCU.

Testing shall be considered successful when it can be shown that:

1) Data to be transmitted from the Investigation to the MLC, is successfully transmitted by the Investigation and read by the MLC.

2) Data to be transmitted from the MLC to the Investigation, is successfully transmitted by the MLC and read by the Investigation.

3) Data to be transmitted from the Investigation to the ISS, is successfully transmitted by the Investigation and read by the PRCU.

4) Data to be transmitted from the ISS to the Investigation, is successfully transmitted by the PRCU and read by the Investigation.

Note: This test shall be performed in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
ISO/IEC 8802-3, MSFC-RQMT-3098

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-09	C&DH –MLC SOFTWARE INTERFACE	IIT	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.3.5.1 MLCS RS232 Interface (T) 3.3.5.2 MLCS Ethernet Interface (T) 3.3.5.3 MLCS Socket Interface (T)

Requirement Summary:

These requirements ensure that the Investigation can communicate with the MLCS software and that the MLC is configured correctly to send and receive data and commands.

Detailed Descriptions of Requirements:

Verification of the MLC Software Interface shall be by test using the MSG Engineering Unit, a Flight Equivalent MLC, and where appropriate the PRCU.

Testing shall be considered successful when it can be shown that:

1) Data to be transmitted from the Investigation to the MLC, is successfully transmitted by the Investigation and read by the MLC.

2) Data to be transmitted from the MLC to the Investigation, is successfully transmitted by the MLC and read by the Investigation.

3) Data to be transmitted from the Investigation to the ISS, is successfully transmitted by the Investigation and read by the PRCU.

4) Data to be transmitted from the ISS to the Investigation, is successfully transmitted by the PRCU and read by the Investigation.

Note: This test shall be performed in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for test.	L-9

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSFC-RQMT-3098
MSFC-RQMT-2888 MSFC-HDBK-3141

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-10	C&DH - ETHERNET PROTOCOL	ISS	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.3.6.2.1 Ethernet Interface Protocol (T)

Requirement Summary:
The Ethernet/Medium-Rate Data Link (MRDL) protocol must comply with ISO/IEC 8802-3 Pics Proforma for 10 Base T.

Detailed Descriptions of Requirements:
Test verification of the investigation hardware shall be performed using an Ethernet network analyzer to insure the MRDL protocol is in accordance with the ISO/IEC 8802-3 Pics Proforma for 10 Base T.

Note: PRCU can provide a port for correct routing of messages.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	Prior to Integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
ISO/IEC 8802-3 (Entire Document)
SSP 52050, Section 3.3.3 & SSP 57000, par. 3.3.6.1, and 3.3.6.1.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-11	C&DH - ETHERNET CONNECTIVITY AND ADDRESSING	ISS	I&T, A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.3.6.2.2 Ethernet Interface Address (A&T)
3.3.6.1.4 Ethernet Interface Connectivity (I&T)

Requirement Summary:

The Ethernet/Medium-Rate Data Link (MRDL) must have proper connectivity to Local Area Networks (LAN), and the addressing must allow software commands and data to be received by the intended recipient.

Detailed Descriptions of Requirements:

A. MRDL Address: Verification of the investigation Ethernet LAN 2 unique address shall be by analysis and test. The analysis shall verify that the unique numbers were issued by IEEE or their representative. The test of the investigation shall verify that the investigation correctly implement the Ethernet protocol with the Ethernet network analyzer. The verification for the investigation shall be considered successful when traceability of addresses to IEEE has been shown and when the protocol meets the requirements of ISO/IEC 8802-3 Pics Proforma for 10 Base T, using an Ethernet network analyzer. Verification of MAC address shall be set prior to the Ethernet terminal going active shall be by test. The test shall verify that the investigation correctly implements the Ethernet protocol with Ethernet network analyzer. The verification shall be considered successful when the protocol meets the requirements of ISO/IEC 8802-3 Pics Proforma for 10 Base T, using an Ethernet network analyzer. This test may be combined with the tests described in the previous paragraph of this VDS.

B. Ethernet Connectivity: Verification of the investigation Ethernet connectivity shall be by inspection. The inspection shall be considered successful when it is shown that the investigation drawings conform to Unique Investigation ICD. Verification of MRDL data routing shall be by test. The test shall be accomplished with the PRCU or equivalent. The test shall be considered successful when it is shown that Ethernet data can be successfully routed to the proper ISS LAN with the correct Ethernet address.

NOTE: PRCU can be used to route MRDL data from the system emulators to the payload a well as routing MRDL data from the payload to the system emulators.

Required Verification Data:	Data Submittal Dates:
1. Test report and Certificate of Compliance (COC) stating compliance with Ethernet protocol. 2. COC for Item B.	1. Prior to Integration Testing 2. L-9

Description of Reverification Requirements:	Reverification Method:	HAZARD REPORT(S):
See section 5.3 for details. Continued on next page		

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-11	C&DH - ETHERNET CONNECTIVITY AND ADDRESSING	ISS	I&T, A&T	

Continued from previous page

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
SSP 52050, par.3.3.6
SSP 57000, par. 3.3.6.1.2 and 3.3.6.1.3
SSP 57001, Tables 3.3.2.2-1 and 3.3.2.2-2
SSP 57002, Tables 3.1.2.2-1 and 3.1.2.2-2
SSP 57300 Software ICD Series Document

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-12	C&DH - EHTERNET CABLE CHARACTERISTICS	ISS	I&T	

MSFC-RQMT-2888 PARAGRAPH NUMBER(S), TITLE(S), AND METHOD(S):
3.3.6.1.1 Ethernet Interface Cable Characteristics (I)
3.3.6.1.3 Ethernet Interface Signal Characteristics (T&I)
3.3.6.1.2 Ethernet Interface Connector / Pin Assignments (I)

Requirement Summary:
The Ethernet/Medium-Rate Data Link (MRDL) cable characteristics (signal characteristics) must meet specific industry standards.

Detailed Descriptions of Requirements:

Cable Characteristics:
The inspection of the investigation Ethernet Cable Characteristics will be complete when it is determined it conforms to MSFC-RQMT-2888 Section 3.3.6.1.1, Table XXVIII.
Connector / Pin Assignments:
The inspection of the investigation Ethernet Connector / Pin Assignments will be complete when it is determined it conforms to MSFC-RQMT-2888 Section 3.3.6.1.2, Table XXIX.
Signal Characteristics:
The inspection of the investigation Ethernet signal characteristics will be complete when it is determined it conforms to section 14.2.1 of ISO/IEC 8802-3 with the exception stated in paragraph 3.3.6.1.3 Note: work with IIT on S/W ICD.
The test of the investigation Ethernet signal characteristics will be complete when it is determined it conforms to section 14.4.2.1 of ISO/IEC 8802-3, 1994, with the exception that the wire meets Table XXVIII.

Required Verification Data:	Data Submittal Dates:
1. Test report and Certificate of Compliance (COC) stating compliance with Ethernet signal characteristics. 2. Certificate of Compliance (COC) for inspection	1. Prior to Integration Testing 2. Prior to Integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

APPLICABLE DOCUMENT(S):
ISO/IEC 8802-3, par. 14.2.1, 14.4.2.1, 14.4.2.2, and 14.4.2.3
SSP 57000, par. 3.3.6, 3.3.6.1.5, 3.3.6.1.6.1, 3.3.6.1.6.2, and 3.3.6.1.6.3; Table 3.3.6.1.6-I
SSP 57300 Software ICD Series Document

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-13	C&DH - VIDEO INTERFACE HARDWARE REQUIREMENTS	IIT	T&I, A or T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.3.7.1.1 Video Interface Cable Characteristics (T&I) 3.3.7.1.2 Video Interface Connector / Pin Assignments (I)
3.3.7.1.3 Video Interface Signal Characteristics (A or T)

Requirement Summary:

These requirements ensure that investigation video interface conform to the MSG video system.

Detailed Descriptions of Requirements:

Testing & inspection shall be performed to verify that the investigation video interface characteristics are in accordance with MSFC-RQMT-2888, Table XXX Video Connector Contact Assignments. The verification shall be considered successful when an inspection of the investigation video connector shows compliance with MSFC-RQMT-2888, Paragraph 3.3.71.2. Testing shall be done with the facility to insure compatibility with the MSG video system.

Analysis or test shall be performed on investigation provided cameras to insure that the power consumption of the camera does not exceed 7.8 watts. The verification shall be considered successful when the analysis or test shows compliance with MSFC-RQMT-2888, Paragraph 3.3.7.1.3.

Investigations shall provide a C.O.C. stating that the cameras provided by the investigation are National Television Committee (NTSC) video standard EIA RS –170A cameras. Investigations shall verify that the video signal has not been changed if processed or additional data has been added.

NOTE: This test shall be performed in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for test or analysis.	1. L-8
2. Certificate of Compliance (COC) for inspection.	2. Prior to integration Testing
3. Certificate of Compliance (COC) for NTSC video standard.	3. Prior to integration Testing

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:
Applicable Document(s):	

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CD-14	C&DH – VIDEO INTERFACE SOFTWARE REQUIREMENTS	IIT	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.3.7.2.1 Video Interface Commands (T)

Requirement Summary:

These requirements ensure that video commands have been correctly identified and can be transmitted from the PRCU to the MSG video system.

Detailed Descriptions of Requirements:

Testing shall be performed to verify that the video system commands are in accordance with 3.3.7.2.1 Commands, of MSFC-RQMT-2888. The verification shall be considered successful when Video commands have been successfully transmitted from the PRCU to the Video System, and the desired actions have been accomplished.

Note: This test shall be performed in the MSG Engineering Unit.

Required Verification Data:	Data Submittal Dates:
Certificate of Compliance (COC) for test.	L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):
MSFC-HDBK-3051
EIA RS170A

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-001	FLUID DYNAMICS – PHYSICAL INTERFACE	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.3.3.9 Fluid and Gas Line Connectors (A)

Requirement Summary:

Connectors of investigation hardware requiring liquid or gas cooling provisions must interface properly, and allowances must be given for access and inspection of the interface components.

Detailed Descriptions of Requirements:

A. Fluid and gas line connectors that are mated and demated on-orbit shall be verified by analysis. Verification shall be considered successful when an analysis of payload flight hardware drawings shows that fluid and gas connectors that are mated and demated on-orbit are located and configured so that they can be fully inspected for leakage.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.1.1.6.1, 3.5.1.1, 3.12.4.3.10, and Table 3.1.1.6.1-1

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Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-002	FLUID DYNAMICS – AIR CIRCULATION SYSTEM	IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.4.1.1 WV Air Circulation System (T&A)

Requirement Summary:

These requirements ensure that the Air Handling Unit (AHU) heat exchanger is capable of removing the air heat load of the investigation temperature range.

Detailed Descriptions of Requirements:
Verification of investigation heat dissipation to the work volume air shall be by analysis. The investigation power draw test data shall be used to determine if the AHU heat exchanger is capable of removing the investigation dissipated heat load. Verification shall be considered successful when the analysis shows that the heat loads defined in the Unique Investigation Hardware ICD are not exceeded. .

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8
2.	2.

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-003	FLUID DYNAMICS – COLDPLATE MOUNTING REQ.	IIT	I & A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.4.1.2.1.a,b,c,d,e Investigation Coldplate Mounting Requirements (T&I&A)

Requirement Summary:

Investigation coldplate interface must be compatible with the following requirements.

Detailed Descriptions of Requirements:

A. Verification of investigation coldplate mounting surface flatness shall be by inspection. Inspection of investigation drawings that the coldplate mounting surface provides a 0.2 mm flatness and a surface finish of 125 microinches on the surface in contact with the coldplate. The verification shall be considered successful when the inspection shows that the mounting surface meet the requirement as specified in MSFC-RQMT-2888 Paragraph 3.4.1.2.1.a.

B. Verification of the bolts used to attach the investigation to the coldplate are torqued to the proper values shall be by inspection. The verification shall be considered successful when the inspection of the crew procedures show that the torque values meet the requirement as specified in MSFC-RQMT-2888 Paragraph 3.4.1.2.1.b.

C. Verification of investigation heat distribution shall be by analysis. The analysis shall show that the investigation provides, to the maximum extent possible, an equal heat distribution over the coldpate surface as specified in MSFC-RQMT-2888 Paragraph 3.4.1.2.1.c.

D. Verification of investigation heat dissipation shall be analysis. The analysis shall insure that the investigation heat dissipation is under the MSG limit as specified in MSFC-RQMT-2888 Paragraph 3.4.1.2.1.d, and the heat loads defined in the Unique Investigation Hardware ICD are not exceeded.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8
2.	2.

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-004	FLUID DYNAMICS – LOSS OF MSG COOLING/SERVICES	IIT	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.4.1.4 Loss of MSG Cooling or Services (A)

Requirement Summary:

This requirement ensures that the investigation remains in a safe condition when MSG services are lost.

Detailed Descriptions of Requirements:
Investigations shall be designed to maintain fault tolerance or safety margins consistent with the hazard potential, e.g. touch temperature, without ground or flight crew intervention, in the event of sudden loss or temporary interruption of the MSG coolant loop or the vacuum and nitrogen services. Verification that the investigation maintain safe margins shall be analysis. The analysis shall insure that the investigation can not produce an unsafe condition, e.g. credible fire hazard, or that parameter monitoring is in place as specified in MSFC-RQMT-2888 Paragraph 3.8.1.1 and shall be tested as required in VDS IIT-CD-002.

Required Verification Data:	Data Submittal Dates:
1.Certificate of Compliance (COC)	1.L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-014	FLUID DYNAMICS - VES PHYSICAL INTERFACE	IIT	I&D&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.1.1 VES Physical Interface (I&D&T)

Requirement Summary:

The investigation Vacuum Exhaust System (VES) mechanical connector must mate correctly.

Detailed Descriptions of Requirements:

A. Verification that the investigation VES connector, as specified in MSFC-RQMT-2888, Paragraph 3.5.1.1.a, physically mates with the corresponding MSG connector shall be by demonstration. The demonstration shall use the MSG EU to verify that the VES connectors physically mate. The verification shall be considered successful when the demonstration shows the investigation connector physically mates with its corresponding MSG facility connector.

B. Verify by test that the leak rate of the investigation volume connected to the VES is less than 2×10^{-3} scc/sec as specified in MSFC-RQMT-2888, Paragraph 3.5.1.1.b.

C. Verify by demonstration that the investigation will not block the manual shut-off valve when connected to the VES system.

D. Gases vented to the VES system shall be within the restrictions as defined in VDS sheets FD-018, FD-019 and FD-020.

E. Inspection of crew procedure that operational instruction are in place for leak tightness check for each unique VES vacuum hose as specified in MSFC-RQMT-2888, Paragraph 3.5.1.1.e.

NOTE: The demonstration can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-015	FLUID DYNAMICS - VES INPUT PRESSURE LIMIT	ISS	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.5.1.2.a Input Pressure Limit (T)
3.5.1.2.b Input Pressure Limit (A&T)
3.5.1.2.c Input Pressure Limit (A)

Requirement Summary:

The investigation vacuum interface must be able to withstand a specified maximum pressure at the VES mechanical connection. The investigation shall also be two failures tolerant to protect against failure conditions that would exceed VES maximum design pressure of 40 psia.

Detailed Descriptions of Requirements:

The investigation volumes shall be able to withstand a maximum pressure of 40 psia as specified in MSFC-RQMT-2888, paragraph 3.5.1.2.a and paragraph 3.5.1.2.b.

A. Investigation vented gas pressure shall be verified by test. The test shall utilize a PRCUto measure the vented gas pressure at the interface plane. The investigation volumes that are connected to VES shall be pressurized to the expected experiment pressures for the test. (Since the PRCU does not provide positive pressures, the investigation volumes that are connected to the VES shall be pre-pressurized to the expected experiment pressure for the test.)

B. Verify by analysis that the investigation volumes connected to the VRS shall be designed to a maximum design pressure of at least 276 kPa (40 psia) with safety factors in accordance with MSFC-RQMT-2888, Paragraph 3.5.1.2.b.

(Note: The PRCU does not proof-test.)

C. Verify by analysis that the investigation system (including the chamber) provides a one fault tolerant design to prevent venting gases at pressures greater than 276 kPa (40 psia) at the interface. Verification shall be considered successful when the analysis shows the investigation system provides a two fault tolerant design to prevent venting gases to the VRS system at pressures at the interface as specified in MSFC-RQMT-2888, Paragraph 3.5.1.2.c.

NOTE: The test can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 52005, par. 5.1.3
SSP 57000, par. 3.6.1.2
SSP 57001, par. 3.6.1
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-016	FLUID DYNAMICS - VES INPUT TEMPERATURE LIMIT	ISS	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.1.3 Input Temperature Limit (T)

Requirement Summary:

The temperature of the investigation vacuum exhaust mechanical interface must be below a specified limit.

Detailed Descriptions of Requirements:

Integrated rack vent exhaust temperature shall not exceed limits as specified in MSFC-RQMT-2888, Paragraph 3.5.1.3 and will be verified by test. The test shall utilize a PRCUto measure the initial temperature at the interface plane. The investigation volumes that are connected to VES shall be pressurized to the expected pressures for the test. The investigation shall be subjected to the same heat generating operations that will be experienced on–orbit and vented at the same relative time during the experiment operation as would be experienced on–orbit.

NOTE: The test can be closed during physical or integrated testing with the EU..

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.6.1.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-017	FLUID DYNAMICS - VES INPUT DEWPOINT LIMIT	ISS	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.1.4 Input Dewpoint Limit (T)

Requirement Summary:

The dewpoint of the investigation vacuum exhaust mechanical interface must be below a specified limit.

Detailed Descriptions of Requirements:

Investigation vent exhaust dewpoint temperature shall not exceed the limits as specified in MSFC-RQMT-2888, Paragraph 3.5.1.4 and will be verified by test. The test shall utilize a PRCUto measure the initial dewpoint at the interface plane. The investigation volumes that are connected to VES shall be pressurized to the expected pressures for the test. The investigation shall be subjected to the same operations that will be experienced on–orbit and vented at the same relative time during the investigation operation as would be experienced on–orbit.

NOTE: The test can be closed during physical or integrated testing with the EU..

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.6.1.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-018	FLUID DYNAMICS - VES ACCEPTABLE EXHAUST GASES	ISS	A or A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.5.1.5.a-d Acceptable Exhaust Gases (A or T)
.3.5.1.5.1 Acceptable Exhaust Gases Initial List (A)

Requirement Summary:

The investigation vented constituents must be compatible with wetted materials of the module VES, and there must be no explosive gas potential.

Detailed Descriptions of Requirements:

A. Verification that exhaust gases vented into the Vacuum Exhaust System (VES) of the USL are compatible with the wetted surface materials of the respective laboratory in which the integrated rack will operate shall be by analysis or test. Gases documented in Appendix D of MSFC_RQMT-2888 have been analyzed for compatibility with the ISS VES wetted materials. The investigation provider shall submit a complete list of all proposed vent gas constituents, initial volume, concentration, temperature, and pressure to the IIT team. The list submitted shall also identify which exhaust gases will be vented together and shall include the products of any reactions determined in paragraph 3.5.1.5.b of MAFC-RQMT-2888. The IIT team will forward this list to the ISS module integrator and they will analyze the list of gases not specified in Appendix D of MSFC_RQMT-2888 and the VES wetted surface materials to determine whether or not the proposed exhaust gases are compatible with the VES wetted materials. The ISS program will evaluate and conduct a test, if necessary, for gases that do not have compatibility documentation to determine whether or not the proposed exhaust gases are compatible with the VES wetted surface. The investigator shall review the investigations proposed vent gases and determine whether or not the gases are listed as acceptable in Appendix of MSFC_RQMT-2888 or on the report provided to the IIT team. Verification shall be considered successful when the proposed exhaust gases are shown to be compatible with the VES wetted surface materials of the respective laboratory in which the investigation will operate.

B. Verification that investigation gases vented to the ISS VES are non-reactive with other gas mixture constituents shall be by analysis. The ISS program will evaluate and conduct an analysis to determine what gases will be vented to the ISS VES and, assuming the worst case reactions possible, shall determine all reactions that are possible among the vent gases constituents. An analysis shall calculate the worst case temperature change associated with the possible vent gas reactions in accordance with the following equation. Verification shall be considered successful when the analysis shows the gases vented to the VES are non-reactive according to the equation.

$$20 \geq \frac{\sum \text{ALL REACTIONS} \left[\left[\frac{(\sum X_P H_P - \sum X_{r1} Hr)}{N_{lim}} \right] m_{lim} \right]}{\sum X_P m_P c_{PP} + \sum X_{r2} m_r c_{pr} + \sum X d m d c p d}$$

Hp = Enthalpy of formation of the products (J/mol)
Hr = Enthalpy of formation of the reactants (J/mol)

XR1 = NUMBER OF MOLES OF THE REACTANTS
Xr2 = Number of moles of the unreacted reactants
Xp = Number of moles of the products
Xd = Number of moles of the diluent
nlim = Molecular Weight of the limiting reactant in the reaction (g/mol)
mlim = Mass of the limiting reactant in the reaction (g)
mp = Mass of each product gas in the vent mixture (g)

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-018	FLUID DYNAMICS - VES ACCEPTABLE EXHAUST GASES	ISS	A or A&T	

mr = Mass of each unreacted reactant gas in the vent mixture (g)
md = Mass of each diluent gas in the vent mixture (g)
cpp = Constant Pressure Heat Capacity of each product gas at the vented condition (J/(g*K))
cpr = Constant Pressure Heat Capacity of each unreacted gas at the vented condition (J/(g*K))
cpd = Constant Pressure Heat Capacity of each diluent gas at the vented condition (J/(g*K))
Note: The exact equation used may vary slightly depending on the units of the data available for the given gases. These variations shall be limited to units conversions only. The final units ofthe equation should be a measure of temperature, measured in Celsius or Kelvin.
For each possible reaction in the vent gas mixture, all gases associated with the reaction shall be included in the calculation in the numerator. All possible reactions in the vent gases mixture shall be calculated and summed together in the numerator. All gases in the vented mixture should be included in the denominator of the analysis. Unreacted reactants may be summed in the denominator as a diluent, when rich or lean mixtures are expected for a given reaction. When lean or rich mixtures are expected for one reaction, an analysis shall show that the excess reactant gases will not react with another gas in the vent mixture (the original reaction considered should be the worst case, i.e. most energy released, reaction).
If trace elements (up to the SMAC value) are present and do not participate in a reaction, they may be excluded from this analysis.
Verification shall be considered successful when the analysis shows the gases vented to the ISS VES/WGS are non–reactive according to the equation specified above (the equation meets the inequality).
Note: Venting of cabin air or the ISS pressurized gases, Nitrogen, Carbon Dioxide, Argon or Helium, or mixtures of these gases are considered acceptable and do not require verification if they are not mixed with other gases.

C. Verification that the investigation venting to the ISS VES provide a means of removing gases that should adhere to the VES tubing walls at a wall temperature of 4°C (40°F) and a pressure of 10^{-3} torr shall be by analysis. An analysis shall determine whether or not the gas mixture contains gases with a molecular weight greater than 75 amu or gases which have a boiling point greater than 100°C (212°F) at atmospheric pressure.
Each proposed vent gas with a molecular weight greater than 75 amu or boiling point greater than 100°C (212°F) at atmospheric pressure shall be analyzed to determine whether or not the vapor pressure is below a pressure of 10^{-3} torr at 4°C (40°F). This analysis shall be conducted gas-by-gas. If any proposed vent gases are determined to have a vapor pressure below 10^{-3} torr at 4°C (40°F), an analysis shall be conducted to determine whether or not the integrated rack provides a means to remove these gases from the vent gas mixture prior to venting to the ISS VES. Verification shall be considered successful when the analysis shows the gases that will be exposed to the ISS VES will not adhere to the ISS VES tubing wall at a wall temperature of 4°C (40°F) and a pressure of 10^{-3} torr. Gases that will be exposed to the ISS VES will not adhere to the ISS VES tubing walls when each vent gas is shown to have a vapor pressure above 10^{-3} torr at 4°C (40°F) or a boiling temperature below 4°C (40°F) at a pressure of 10^{-3} torr and/or, any gases found with a vapor pressure below 10^{-3} torr at 4°C (40°F) or a boiling temperature above 4°C (40°F) at a pressure of 10^{-3} torr are removed from the gas mixture.

D. Verification that investigations venting to the ISS VES remove particulates from the vent gases that are larger than 100 micrometers shall be by analysis. An analysis shall determine whether or not the vent gases will contain particulate contamination larger than 100 microns. Should the analysis show that particulate contamination greater than 100 microns will be introduced into, or generate in, the vent gases, an analysis shall determine whether or not a means of removing the particles above 100 microns before venting to the ISS VES is included in the investigation design. Verification shall be considered successful when the analysis shows the vent gases will not contain particulate contamination greater than 100 microns.

Required Verification Data:	Data Submittal Dates:
1. Preliminary Data Cert. providing constituents of vented gas, volume, concentration, temperature, and pressure.	1. L-20
2. Data Cert. providing updated constituents of vented gases, volume, concentration, temperature, and pressure (if required).	2. L-12
1. Data Cert. For Item C, showing that investigation venting in the ISS VES provides a means to remove gases that should adhere to the VES tubing wall.	3. L-12

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-018	FLUID DYNAMICS - VES ACCEPTABLE EXHAUST GASES	ISS	A or A&T	

2. Data Cert. For Item D, showing that all particulates larger than 100 microns are removed prior to venting to the VES.	4. L-12

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.6.1.5

NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-019	FLUID DYNAMICS - EXTERNAL CONTAMINATION CONTROL	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.5.1.5.2 External Contamination Control (A)
3.9.1.2.E ADDITIONAL INVESTIGATION MATERIALS REQ.

Requirement Summary:

Vented constituents must not exceed the specified external contamination limits.

Detailed Descriptions of Requirements:

Verification shall be by analysis. The investigation shall submit the list of vented gas constituents, volume, temperature, and pressure to the IIT team, per requirement FD-18.

The verification shall be considered successful when the Environments Team verifies that the vented gases do not exceed the external contamination limits as specified in SSP 30426, paragraph 3.4. & MSFC-RQMT-2888 Paragraph 3.5.1.5.2

Required Verification Data:	Data Submittal Dates:
1. Preliminary Data Cert providing the required list of vented gas characteristics (vented gas constituents, volume, temperature, and pressure).	1. L-20
2. Updated Data Cert (if required).	2. L-12

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 30426 par. 3.4
SSP 57000 par. 3.6.1.5.2

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-020	FLUID DYNAMICS - INCOMPATIBLE GASES	ISS	A&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.1.5.3 Deleted

Requirement Summary:

Detailed Descriptions of Requirements:

Deleted

Required Verification Data:	Data Submittal Dates:

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 52005, par. 5.1.3
SSP 57000, par. 3.6.1.5.3
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-021	FLUID DYNAMICS - VRS PHYSICAL INTERFACE	IIT	I & T & D	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.2.1.a-e VRS Physical Interface (I & T & D)

Requirement Summary:

The investigation Vacuum Resource System (VRS) mechanical connector must mate correctly and meet the following requirements.

Detailed Descriptions of Requirements:

A. Verification that the investigation VRS connector, as specified in MSFC-RQMT-2888, Paragraph 3.5.2.1.a, physically mates with the corresponding MSG connector shall be by demonstration. The demonstration shall use the MSG EU to verify that the VRS connectors physically mate. The verification shall be considered successful when the demonstration shows the investigation connector physically mates with its corresponding MSG facility connector.

B. Verify by test that the leak rate of the investigation volume connected to the VES is less than 2 X 10^{-3} scc/sec as specified in MSFC-RQMT-2888, Paragraph 3.5.2.1.b.

C. Verify by demonstration that the investigation will not block the manual shut-off vavle when connected to the VRS system.

D. Gases vented to the VRS system shall be within the same restrictions as for VES vented gases as defined in VRDS sheets FD-018, FD-019 and FD-020.

E. Inspection of crew procedure that operational instruction are in place for leak tightness check for each unique VRS vacuum hose as specified in MSFC-RQMT-2888, Paragraph 3.5.2.1.e.

NOTE: The demonstration can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-022	FLUID DYNAMICS - VRS INPUT PRESSURE LIMIT	ISS	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.2.2.a-c Input Pressure Limit (A&T)

Requirement Summary:

The interface pressure from the investigation to VRS must not exceed specific limits.

Detailed Descriptions of Requirements:

A. Verify by test that the interface pressure from the integrated rack to VRS will not exceed 10^{-3} Torr at the interface plane as specified in MSFC-RQMT-2888 Paragraph 3.5.2.2.a.
Note: PRCUwill be able to monitor VRS throughput.

B. Verify by analysis that the investigation volumes connected to the VRS shall be designed to a maximum design pressure of at least 276 kPa (40 psia) with safety factors in accordance with MSFC-RQMT-2888, Paragraph 3.5.2.2.b.

C. Verify by analysis that the investigation system (including the chamber) provides a one fault tolerant design to prevent venting gases at pressures greater than 276 kPa (40 psia) at the interface. Verification shall be considered successful when the analysis shows the investigation system provides a two fault tolerant design to prevent venting gases to the VRS system at pressures at the interface as specified in MSFC-RQMT-2888, Paragraph 3.5.2.2.c.

NOTE: The test can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 52005, par. 5.1.3
SSP 57000, par. 3.6.2.2
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-023	FLUID DYNAMICS - VRS THROUGH-PUT LIMIT	ISS	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.5.2.3 VRS Through-Put Limit (T)

Requirement Summary:

Throughput pressure at the VRS mechanical connection must be within specified limits.

Detailed Descriptions of Requirements:

Testing shall be used to verify that the throughput to the VRS interface shall be limited to 1.2 X 10^{-3} scc/sec as specified in MSFC-RQMT-2888, Paragraph 3.5.2.3. The test shall utilize a PRCUto measure the vented gas throughput at the interface plane.

NOTE: The test can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.6.2.3
SSP 57001, par. 3.6.2B

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-024	FLUID DYNAMICS - PRESSURIZED GASES INTERFACE CONTROL (NITROGEN)	ISS	T & I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.6.1.2 Nitrogen Interface Control (T)
3.6.1.5 Nitrogen Operational Constraints. a - .d (I)

Requirement Summary:

The investigation must be capable of controlling the flow (on and off) of pressurized nitrogen gas supply system when connected to it. Investigations shall incorporate the operational constraints into their crew procedures when using the nitrogen supply system.

Detailed Descriptions of Requirements:

Verification of gaseous flow control shall be by test. The verification shall be considered successful when the test results confirm that the investigation can turn the flow of gas on and off. The MSG facility maintains the gas flows below the pressurants maximum flow rate. The maximum allowable flow rate is applicable over the pressurants operating range in accordance with MSFC-RQMT-2888, Paragraph 3.7.1.1. (The PRCU can be used for nitrogen testing.)

Investigations shall incorporate into their crew procedures the operator instructions in MSFC-RQMT-2888 Paragraph 3.6.1.5.a through .d when using the nitrogen supply system. Verification shall be considered successful when an inspection of the crew procedures shows that the procedures are incorporated into the investigation's crew procedures.

NOTE: The test can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for interface control.	1. L-8
2. Certificate of Compliance (COC) for crew procedures	2. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.7.1.1, 3.7.2.1, 3.7.3.1, and 3.7.4.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-025	FLUID DYNAMICS -MDP (NITROGEN) PRESSURIZED GASES INTERFACE	ISS	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.6.1.3 Nitrogen Interface Pressure (A&T)

Requirement Summary:

The Maximum Design Pressure (MDP) of investigation hardware connected to the pressurized nitrogen gas supply system must comply with pressure requirements.

Detailed Descriptions of Requirements:

The MDP of investigation volumes connected to the nitrogen gaseous supply system shall be verified by the test and analysis guidelines as specified in SSP 52005, paragraph 5.1.3 and NSTS 1700.7 ISS addendum for pressure vessels. The MDP of any hardware interfacing with referenced pressurant systems shall be 1,379 kPa (200 psia), in accordance with MSFC-RQMT-2888 Paragraph 3.6.1.3.

Required Verification Data:	Data Submittal Dates:
1. Data identified for Phase Safety Review II in accordance with SSP52005, Table 9.2.2-1.	1. L-15
2. Data identified for Phase Safety Review III in accordance with SSP52005, Table 9.2.2-1.	2. L-12

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 52005, par. 5.1.3
SSP 57000, par. 3.7.1.2, 3.7.2.2, 3.7.3.2, and 3.7.4.2
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-026	FLUID DYNAMICS - PRESSURIZED GASES INTERFACE TEMPERATURE (NITROGEN)	ISS	A or T or A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

Deleted

Requirement Summary:

Detailed Descriptions of Requirements:

Deleted

Required Verification Data:	Data Submittal Dates:

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.7.1.3, 3.7.2.3, 3.7.3.3, and 3.7.4.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-027	FLUID DYNAMICS - NITROGEN PHYSICAL INTERFACE & LEAKAGE	ISS&IIT	I &T	

MSFC-RQMT-2888 Paragraph 4 Number(s), Title(s), and Method(s):

3.6.1.1.a Physical Interface (I)
3.6.1.1.b Nitrogen Leakage (T)

Requirement Summary:

The investigation provided QD shall be of the correct type, and the pressurized nitrogen gas supply systems, fluid leakage at the MDP of the investigation hardware must be less than allowable limits.

Detailed Descriptions of Requirements:

A. Verification of investigation nitrogen interface shall be by inspection. The verification shall be considered successful when an inspection of the investigation drawings shows that the correct QD connector is being used in accordance with MSFC-RQMT-2888, Paragraph 3.6.1.1.a.

B. Verification of investigation gaseous leakage shall be by test. The verification shall be considered successful when the test results show that the sum of all potential leakage sources from the QD connection to the point of pressurized nitrogen gas interface to the investigation does not exceed the allowable leakage rate at MDP in accordance with MSFC-RQMT-2888, Paragraph 3.6.1.1.b.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for correct QD	1. L-8
2. Data Cert providing leakage test results in scc per sec. If a representative gas is used to determine leakage (i.e. helium), conversion factors used for the subject gas are to be provided.	2. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.7.1.4, 3.7.2.4, 3.7.3.4, and 3.7.4.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-FD-028	FLUID DYNAMICS - PRESSURIZED GAS BOTTLES	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.6.2 Pressurized Gas Bottles (A)

Requirement Summary:

The maximum leak rate of pressurized gas bottles transported in the MPLM must not exceed the specified limit.

Detailed Descriptions of Requirements:

Verification of the expanded volume and flow rate for pressurized gas systems shall be by analysis. The verification shall be considered successful when the analysis of the drawing's shows that the expanded volume of the gas in the pressurized system is below the limiting volume specified in MSFC-RQMT-2888, Paragraph 3.6.1. If the volume exceeds the limiting volume, then an analysis must be performed verifying that the flow rate after a single failure does not exceed the maximum allowable amount after release of the limiting expanded volume as defined in MSFC-RQMT-2888, Paragraph 3.6.1.

Required Verification Data:	Data Submittal Dates:
1. Data Cert providing maximum credible leak rate (in slpm) for each bottle.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.7.5

NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-001	ENVIRONMENTAL - ATMOSPHERE HUMIDITY	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.7.1.3 Humidity (A)

Requirement Summary:

Investigation surfaces must preclude formation of condensation when exposed to a specified humidity and dewpoint range.

Detailed Descriptions of Requirements:

Analysis shall be used to verify that the investigation is designed to not cause condensation when exposed to the specified dewpoint and relative humidity except when condensation is an intended operation of the investigation. The verification shall be considered successful when analysis shows that no internal or external surfaces will allow condensation over humidity and dewpoint ranges as specified in MSFC-RQMT-2888, Paragraph 3.7.1.3. Surfaces shall be considered to be in contact with the air unless a volume is hermetically sealed or environmentally conditioned to control humidity.

Required Verification Data:	Data Submittal Dates:
1. Analysis report including: - Description of condensation collection system - Illustration of all components or surfaces where condensation is most likely to occur when the cabin humidity exceeds the nominal case. - Upper humidity limit in terms of dewpoint.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.9.1.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-002	ENVIRONMENTAL -ACTIVE AIR EXCHANGE	ISS&IIT	A&I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.7.4.1 Active Air Exchange (I)
3.7.4.4 Cabin Air Heat Leak (A)

Requirement Summary:

Investigation equipment air exchange with the cabin is limited by specimen metabolic, mass conservation, and heat rejection constraints.

Detailed Descriptions of Requirements:

A. Inspection shall be used to verify that active air exchange with the cabin atmosphere by an integrated rack is limited to air exchange for specimen metabolic purposes and for mass conservation purposes. The verification shall be considered successful when inspection of the flight drawings shows that the active air exchange with the cabin atmosphere by an investigation is limited to air exchange for specimen metabolic purposes and for mass conservation purposes.

B. Verification that investigation equipment heat loads imposed on cabin air is within the specified limits for each module shall be by analysis. The verification shall be considered successful when the analysis shows that investigation equipment cabin air heat loads comply with the values as specified in the Unique Investigation Hardware ICD.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.9.2.1

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-003	ENVIRONMENTAL - OXYGEN CONSUMPTION	ISS	A	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.7.4.2 Oxygen Consumption (A)

Requirement Summary:

Investigation consumption of atmospheric oxygen must not exceed the daily allowable.

Detailed Descriptions of Requirements:

Verification that the investigation consumption of atmospheric oxygen does not exceed the specified amount shall be by analysis. The verification shall be considered successful when analysis shows that the investigation consumption of atmospheric oxygen shall not exceed 1.08 kg per day (2.38 lbm per day) as specified in MSFC-RQMT-2888, Paragraph 3.7.4.2.

Required Verification Data:	Data Submittal Dates:
1. Data Cert providing the investigation oxygen consumption analysis results.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 57000, par. 3.9.2.2

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-005	ENVIRONMENTAL - MICROGRAVITY ENVIRONMENT	ISS&IIT	A&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.1.2.1 Quasi-Steady Requirements (A&T)
3.1.2.2 Vibratory Requirements (TBD) (A&T)
3.1.2.3 Transient Requirements (A&T)
3.1.2.5 Angular Momentum Limits (NVR or A)

Requirement Summary:

Payloads shall not exceed maximum allowable quasi-steady, vibratory or transient microgravity disturbance limits.

Detailed Descriptions of Requirements:

A. Investigation hardware shall meet the quasi-steady, vibroacoustic, and transient disturbance requirements as specified in MSFC-RQMT-2888, paragraph 3.1.2.

i. Quasi-steady - Forces produced by an investigation below 0.01 Hz shall be verified by analysis against 3.1.2.1. This analysis shall be considered successful when it is shown that no impulse is exerted by the investigation to the MSG, either directly or through the MSG vent/exhaust systems, greater than 10 lb–s (44 N–s) over any 10 to 500 second interval.

ii. Vibroacoustic – TBD

iii. Transient –

a. Verification of maximum transient impulse shall be by analysis or test. Acceptable test methods are defined in TBD. Verification shall be considered successful when the impulse delivery by an integrated rack or non–rack payload over any 10 second period is shown to be less than 10 lb s (44 N s) and when the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of 3.1.2.2 (TBD) over any 100 second period. FEM time domain analysis is an acceptable verification method for this requirement as defined in 3.1.2.2(TBD). Acceleration or force response test data is acceptable if interface impedance considerations are included, including adjustment for possible modal frequency shift and interface structural amplification or attenuation.

b. The maximum force at the investigation interface, as determined by either analysis or test, shall be less than 1000 lb (4448 N) in any direction. Rigid body analysis may be used if it can be shown that the rigid payload force to a rigid interface will not exceed 500 lb (2224 N).

NVR if no disturbance force or moments that generate pure internal angular momentum impulse greater than 100 ft-lb-as stated in section 3.1.2.5. Investigation that generate pure internal angular momentum impulse greater than the limit shall work with IIT as stated in section 3.1.2.5.

Required Verification Data:	Data Submittal Dates:
1. Preliminary Analysis/Test Report 2. Final Analysis/Test Reports	1. L-15 (input to IR datapackage) 2. L-10

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:
Continued on next page	

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-005	ENVIRONMENTAL - MICROGRAVITY ENVIRONMENT	ISS&IIT	A&T	

Continued from previous page

Applicable Document(s):

SSP 57000, par. 3.1.2.1, 3.1.2.2, 3.1.2.3, and 3.1.2.5.3
SSQ 21635

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-006	ENVIRONMENTAL - ACOUSTIC LEVELS	ISS	T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.10.2.2.3.a Continuous Noise Limits (A&T)
3.10.2.2.3.b Intermittent Noise Limit (A&T)

Requirement Summary:
Investigation equipment acoustic levels must not exceed specified values.

Detailed Descriptions of Requirements:

A. Continuous Acoustic Noise - The investigation equipment shall not exceed the continuous acoustic noise requirements as specified in MSFC-RQMT-2888, Paragraph 3.10.2.2.3.a Continuous noise sources which exhibit intermittent acoustical characteristics must meet both the continuous noise specification and the intermittent noise requirements of paragraph B below.
   i. Verification of continuous noise sources for investigation equipment shall be performed by test. Sound Pressure Level (SPL) test measurements shall be made on the flight hardware as it would be during on-orbit operations. Measurements shall be made on all sides of the investigation hardware. The SPL test shall use a Type 1 Sound Level Meter to measure the SPL at the loudest location 0.6 meters from the surfaces. SPL shall be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. Verification shall be considered successful when the test shows that the loudest noise on equipment surfaces exposed directly to the crew habitable volume does not exceed the levels as specified in MSFC-RQMT-2888, Paragraph 3.10.2.2.3.a. An integrated analysis will be done on investigation equipment unable to meet the specified levels to see if the WV attenuates any noise

B. Intermittent Acoustic Noise - The investigation equipment shall not exceed the intermittent acoustic noise requirements as specified in MSFC-RQMT-2888, Paragraph 3.10.2.2.3.b. Intermittent noise characteristics shall be quantified in terms of (1) when the intermittent sound occurs, (2) duration and A-weighted SPL, and (3) a projected mission timeline(s). Intermittent noise sources which also exhibit continuous acoustical noise characteristics must meet both the intermittent noise requirements and the continuous noise specification of paragraph A above.

   i Verification of intermittent noise sources for investigation equipment shall be performed by test. The SPL test shall use a Type I sound Level Meter to measure the SPL at the loudest location 0.6 meters from the surfaces. SPL shall be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 hertz. Also, Overall A-weighted SPL (dBA) shall be measured.
   Verification shall be considered successful when the test shows the investigation hardware or integrated rack overall A-weighted SPL (dBA) does not exceed the levels as specified in MSFC-RQMT-2888 Paragraph, 3.10.2.2.4.b.

Required Verification Data:	Data Submittal Dates:
Final Submittal of A&B data listed below 1. Continuous Noise Source – SPL (dB) for the eight octave bands (for each serialized unit) 2. Intermittent Noise Source - SPL (dB) for the eight octave bands and Overall A-weighted SPL (dBA) (for each serialized unit)Intermittent Noise Source - SPL (dB) for the eight octave bands and Overall A-weighted SPL (dBA) (for each serialized unit) Continued on next page	1. L-10 (with further updates as required.)

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-006	ENVIRONMENTAL - ACOUSTIC LEVELS	ISS	T	

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
Continued from previous page		

Required Reverification Data:

See section 5.3 for details.

Applicable Document(s):

SSP 57000, par. 3.12.3.3.1, 3.12.3.3.2, and Tables 3.12.3.3.1-1 and 3.12.3.3.2-

Number	Title	Purpose	Method	Hazard Report(s)
IIT-EN-007	ENVIRONMENTAL – WORK VOLUME ENVIRONMENTAL	IIT	A or T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.7.3.a,b,d,e,f WV Environment (A or T)

Requirement Summary:

Investigation hardware shall meet the specified WV environment compatibility requirements.

Detailed Descriptions of Requirements:

A. Verification of the investigation hardware exposed to the WV negative pressure of $\geq$1.3 mbar relative to cabin pressure shall be by analysis. The verification shall be considered successful when the analysis shows that the hardware is structurally sound when exposed to the WV negative pressure as specified in MSFC-RQMT-2888, Paragraph 3.7.3.a.

B. Investigation shall not cause an overpressurization of the WV, that being 20 mbar negative Δp and 15 mbar positive Δp. The verification shall be considered successful when the analysis shows that the hardware can not cause an overpressurization of the WV as specified in MSFC-RQMT-2888, Paragraph 3.7.3.b.

C. Verification of investigation hardware integrated into the MSG WV shall be compatible with the dimensions specified in MSFC-RQMT-2888, Paragraph 3.7.3.d. The verification shall be considered successful when the fit check (test with facility) shows that the hardware is compatible with the WV dimensions and exclusion zone requirements are satisfied.

Note: Test shall be done using the EU.

D. Verification of investigation hardware to be transferred to the WV through the side port shall be compatible with the dimensions specified in MSFC-RQMT-2888, Paragraph 3.7.3.e. The verification shall be considered successful when the analysis of the hardware drawings or fit check (test with facility) shows that the hardware is compatible with the side port dimensions.

Note: Test shall be done using the EU.

E. Verification of investigation hardware to be transferred to the WV through the airlock shall be compatible with the dimensions specified in MSFC-RQMT-2888, Paragraph 3.7.3.f. The verification shall be considered successful when the analysis of the hardware drawings or fit check (test with facility) shows that the hardware is compatible with the airlock dimensions.

NOTE: The test can be closed during physical or integrated testing with the EU.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC) for item A, B, C and D explicitly.	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Number	Title	Purpose	Method	Hazard Report(s)
IIT-MP-002	MATERIALS - CLEANLINESS	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.9.2 Cleanliness (I)

Requirement Summary:

Investigation provided equipment surfaces must meet certain criteria for surface cleanliness and the equipment exposed surfaces can be cleaned.

Detailed Descriptions of Requirements:

Verification that investigation equipment conform to Visibly Clean-Sensitive (VC-S) cleanliness requirements as specified in SN-C-0005 shall be by inspection. An inspection of the cleanliness documentation required by precision cleaning shall be performed to show that each assembly part, component, subsystem, and system of the end product meets the VC-S requirement. Verification shall be considered successful when the inspection shows that each part, component, subsystem, and system of the end product meets the VC-S requirements.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SN-C-0005
SSP 57000, par. 3.11.3

Number	Title	Purpose	Method	Hazard Report(s)
IIT-MP-003	MATERIALS - FUNGUS RESISTANT MATERIAL	ISS	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
3.9.1.2.e Fungus Resistant Material (I)

Requirement Summary:

Investigation equipment that is intended to remain on orbit for more than one year must use fungus-resistant materials according to specific criteria.

Detailed Descriptions of Requirements:

Inspection shall be used to verify that investigation equipment that is intended to remain on-orbit for more than one year use fungus resistant materials according to the requirements as specified in SSP 30233, paragraph 4.2.10. Inspection of design drawings and materials lists shall determine whether fungus resistant materials have been used as required. Verification shall be considered successful when the inspection shows fungus resistant materials are used as required.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details.		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

SSP 30233, par. 4.2.10
SSP 57000, par. 3.11.4

Number	Title	Purpose	Method	Hazard Report(s)
IIT-MP-004	MATERIALS – ADDITIONAL INVESTIGATION MATERIAL REQ.	IIT	A&I&T	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):

3.9.1.2.a,b,c,d,&g Additional Investigation Material Requirements (A&I&T)
3.7.3.c WV Environment (list of materials)

Requirement Summary:

The investigation hardware shall comply with the material requirement as specified herein.

Detailed Descriptions of Requirements:

A. Investigation hardware shall meet the Materials and Parts use and selection requirements as specified in MSFC-RQMT-2888 Paragraph 3.9.1. Verification shall be considered successful when Hazard report is approved.

B. Investigation hardware shall meet the offgassing acceptance requirements as specified in MSFC-RQMT-2888, Paragraph 3.9.1.2.a. Verification shall be considered successful when Hazard report is approved.

C. Materials and byproducts (combustion) used by the investigation that are not listed in MSFC-RQMT-2888 Table XXXIII or exceed the values given in Table XXXIII shall be approved by the IIT. A list of the materials, byproducts and their quantity shall be provided to the IIT for approval. The investigation shall provide this list to the JSC Toxicology Group and comply with the labeling standards as specified in MSFC-RQMT-2888, Paragraph 3.9.1.2.g.

D. Investigations shall provide their own cleaning equipment (approved by the IIT) in case of spillage and take care of waste disposal. Verification shall be considered successful when the crew procedures show that the investigation has proper equipment and procedures in place to meet the requirements as specified in MSFC-RQMT-2888, Paragraphs 3.9.1.2.d & f.

E. Materials that could be released and byproducts produced by an investigation shall be compatible with the MSG WV surfaces, Air Lock surfaces, filters, gloves and any other supplied hardware. Verification shall be considered successful when the analysis confirms compliance with requirement 3.9.1.2.b. A list of the WV materials the investigation shall be compatible with is provided in Appendix F of this document. Additional information on the MSG filters can be found in the section 4.1.4, MSFC-HDBK-3051.

F. Investigation materials and byproducts considered catastrophic, incompatible with MSG hardware or volumes considered to large if released in the WV shall maintain two or more levels of containment, depending on the toxicological hazard determined by the PSRP, during operations. Verification shall be considered successful when Hazard report is approved for requirement 3.7.4.3. And an analysis confirms compliance with requirement 3.9.1.2.c.

Note: The IIT is responsible for the cross compatibility analysis of the MSG filters with investigation materials and byproducts between two or more investigations. This analysis is part of the Integrated Phase III Safety Package.

Required Verification Data:	Data Submittal Dates:
1. Preliminary list of the materials and byproducts to the IIT for approval.	1. L-20
2. Final list providing all the materials and byproducts to the IIT for approval, (additional updates as required).	2. L-12
3. Data Cert. with any update/changes to the materials and byproducts list.	3. L-8
4. Data Cert. stating compliance with section 3.9.1.2.b.&c.	4. L-8
5. C.O.C. stating compliance with section 3.9.1.2.d & f.	5. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details		

Continued on next page

Number	Title	Purpose	Method	Hazard Report(s)
IIT-MP-004	MATERIALS – ADDITIONAL INVESTIGATION MATERIAL REQ.	IIT	A&I&T	

Required Reverification Data:	Data Submittal Dates:
Continued from last page	

Applicable Document(s):
NSTS.1700.7

Number	Title	Purpose	Method	Hazard Report(s)
IIT-CP-001	CREW PROCEDURE – Procedural Hazard Controls	IIT	I	

MSFC-RQMT-2888 Paragraph Number(s), Title(s), and Method(s):
2.10.8.5.a - .k Procedural Hazard Controls

Requirement Summary:

The investigation hardware shall comply with the procedural hazard controls as specified in section 3.10.8.5.

Detailed Descriptions of Requirements:

Investigations shall incorporate into their crew procedures the following operator instructions that control hazards identified by the PSRP. Investigations shall be responsible for using crew procedures to control the MSG hazards specified in section 3.10.8.5. Depending on the investigation, some of these hazards may not be applicable. Verification shall be considered successful when an inspection of the crew procedures shows that all applicable procedures are incorporated into the investigation's crew procedures.

Required Verification Data:	Data Submittal Dates:
1. Certificate of Compliance (COC).	1. L-8

Description of Reverification Requirements:	Reverification Method:	Hazard Report(s):
See section 5.3 for details		

Required Reverification Data:	Data Submittal Dates:

Applicable Document(s):

Appendix F
MSG Material Compatibility List

MSG Part/Structure	Location/Use	Detailed Material Information
WV Structure	Base Material for WV	AL 1050, 99.5%Al Sheet, Solomon's, DIN 1748, C.o.C, EN-10204, Machining, Alodyning, Nickel Plating, MAPTIS 50202
WV Structure	Base Material for WV	AL 6082, AlSi1MgMn, Sheet, T651, Salomin's, DIN 1725/1788/1784, C.o.C, EN-10204, Machining, Alodyning, Nickel Plating, Primer and Painting, MAPTIS 50278
WV Structure	Base Material for WV	AL 7075, AlZnMgCu 1.5 Plate, T7351, Salomon's, QQ-A-205/13 LN9073, DIN 29546, EN-10204, Machining, Nickel Plating, MAPTIS 50669
Welding Filler		Welding Filler LMN 304L Si, ER 308L SI, Wire. Lincoln Smithweld/Beljaars, ASW A5.9, EN-10204, MAPTIS 53636
Captive Screws		A2-70 / Cres 300 Series, X5 CrNi 1812 Bar, DIN 267, Teil 11, EN-10204, MAPTIS 10268
WV Filter housing		AL 6082, AlSi1MgMn, Sheet, T651, Salomin's, DIN 1725/1788/1784, C.o.C, EN-10204, Anodised to MIL-A-8625 Type II-Class 2 (GOLD)
Lexan with MarGuard	Front Window	Poly Carbonate, AS 4000 Hard Coating, General Electric Plastics/Vink, Lexan 9030, C.o.C, EN-10204, WSTF-99-34685
Lexan	Light covers X 3 & Loading Ports X 2	Lexan F2000, Poly Carbonate, AS 4000 Hard Coating, General Electric Plastics/Vink, Lexan F2000, C.o.C, EN-10204, WSTF-99-34684, WSTF-99-34567, WSTF-99-34430
Screen Material	General Protection cover for Air In/Outlet, I&CC Panel, Illumination Window	Wire Mesh, AISI 304/1.4301, X 5 CrNi 1810
Flapper Unit & Rear Filter Non Return Valves		Silicone Rubber, Diacor/Stony Cove Marine Trials, 0240-15, C.o.C, EN-10204, MAPTIS 07280
Scotch Weld DP-190	Used to seal Light Covers and WV joints	Scotch Weld DP-190 Gray, Eposy, Double Component, 3M, DP-190, C.o.C, EN-10204, MAPTIS 67259
Loctite, on Fasteners	All Bolt and Screw Connections, Except all Captive Screws	Threadlock Loctite 234, Methacrylate Ester, Single Component, Loctite, Loctite 234, C.o.C, EN-10204, MAPTIS 03817/03826
Loctite, on Captive Fasteners	Captive Screws	Threadlock Loctite 222, Dimethacrylate Ester, Single Component, MIL-S-46163A, Loctite, Loctite 222, C.o.C, EN-10204, MAPTIS 06354
Gloves Neoprene	Potentially 4 in Wv and one in Airlock	Gloves, Lightweight 602 Series, Neoprene, Cornasec Yate Ltd, C.o.C, EN-10204, MAPTIS 05433 (Accepted for USML 1-2, MGBX 1-4)

MSG Part/Structure	Location/Use	Detailed Material Information
Helicoils	Used in each investigation mounting area on back wall, cold plate, Airlock Lid, Top mounting area	Ame-Coil Insert (SIM. To Heli-Coil) & Heli-Coil Insert, AISI 304, X5CrNi 1810, CRES 304, Passivated, Ameca & Heli-Coil/Beljaars, Mil-C-83488c/NAS1222, DIN 267, C.o.C, EN-10204
Stainless Steel Inserts	Used in each investigation mounting area on back wall, cold plate, Airlock Lid, Top mounting area	AISI 304
Fire Hole Assembly		Scotch 425, Aluminium with Acrylic Adhesive, 3M, Fed Spec L-T-80, C.o.C, EN-10204,
Viton O-Ring Seals	Used around Gloverings, loading ports and Airlock lid and front door	Viton V747-75, Fluorcarbon Elastomer, O-Rings, Parker Hannifin PLC, C.o.C, EN-10204, MAPTIS 60643
Sealent	Filter Bank Sealing (used between metal parts)	VMQ Silicone Formed Cord, Silicone Rubber Ethyl and Methyl, Cord, BIW Isolierstoffe GmbH, BIW No. 33010273, C.o.C, EN-10204
Black Paint for labels & White Paint on ICP	CMP, PDC, ICP Panels and Markings	830R Primer with 1mron 700 Paint, Epoxy Primer / Polyurethane Coating, Paint, DuPont, C.o.C, EN-10204
Toggle Switches on ICP		Professional Toggle Switch, Misc, Type 12164, Mors, ESA/SCC 3701-001, C.o.C, EN-10204,
Switch Sealing Boots on ICP		Sealing Boots U1031, Boot: Silicone, Nut: Brass, Mors Components, C.o.C, EN-10204,
GN2 Valve	1	Needle Valve SS-1RS-A, AISI 316 Body, Swagelok/Whitey, Catalog MS-01-43, C.o.C, EN-10204
Vacuum Valves	2	Ball Valve 2200K 6T/15, Nickel Plated Brass Body, Ubel, C.o.C, EN-10204
Filters	Misc (Al, HEPA (to collect particles), Monolith (for conversion of CO to CO2), Carbon (Activated for adsorption of solvents))	Filters, 500.104.AA/500.104.AB, C.o.C, EN-10204, Polyester/Polycarbonate Micromelt, Type : CAB 06, Fibermark Gessner / Filtex, Lipseal, Norsorex 150 NA, Ravestein
MSG Provided cables	If required MSG can assist in assessing the impact of having this Item in the work volume. Operational constraints can be used to mitigate risk.	
Hatachi Cameras	If required MSG can assist in assessing the impact of having this Item in the work volume. Operational constraints can be used to mitigate risk.	

MSG Part/Structure	Location/Use	Detailed Material Information
Sony Monitors	If required MSG can assist in assessing the impact of having this Item in the work volume. Operational constraints can be used to mitigate risk.	
MLC Computer	If required MSG can assist in assessing the impact of having this Item in the work volume. Operational constraints can be used to mitigate risk.	
Video Touch Pad	If required MSG can assist in assessing the impact of having this Item in the work volume. Operational constraints can be used to mitigate risk.	

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APPENDIX G
OPEN ITEMS AND PRINS INCORPORATED INTO REVISION C and D

Table XXXVIII. To Be Determined Items

TBD No.	Description	Document Section	Page No.	Reason
1	Vibratory Requirement	3.1.2.2	15	Need information from MSG

Table XXXIX. PRINS Incorporated into MSFC-RQMT-2888

PIRN Number	Title	Assessment/Comments
SSP57000RE	Revision E to SSP57000	Changes to Rev E were incorporated into Rev B of MSFC-RQMT-28888
SSP57000-NA-0214C	Add Missing Table Defining Hand Sizes	Incorporated requirement for investigations to provide handles if larger than $1ft^3$.
SSP57000-NA-0240G	Update to Payload Labeling Requirements	Incorporated applicable changes for investigations regarding labeling requirements/information.
SSP57000RF	Revision F to SSP57000	Changes to Rev F were incorporated into Rev D of MSFC-RQMT-28888
SSP57000-NA-0276	Reduction of ECLS/TCS Requirements	Deleted Incompatible Gases requirement and added it as a note in Acceptable Exhaust Gases, Changed shall statement to will for Nitrogen temperature
SSP57000-NA-0279	Implementation of Materials Requirements Reduction Changes to SSP57000	Deleted Commercial Parts section and added it to Materials and Parts use section.

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